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The Influence of Cultural Practices on Arthropod Populations in Cotton

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The Influence of Cultural Practices on Arthropod Populations in Cotton

By Perry A. Glick, *entomologist (retired), Agricultural Research Service*

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The author thanks R. W. Baird, project supervisor of the Blacklands Experimental Watershed; staff and support personnel at the Blacklands Experimental Watershed; L. S. Dillon, E. S. Dillon, F. L. Thomas, V. A. Little, H. J. Reinhard, and J. C. Gaines of Texas A&M University; and C. F. Rainwater, W. L. Murphy, and the insect identification staff of the U.S. Department of Agriculture; all of whom helped identify the many thousands of insects collected.

The research reported in this publication was done in cooperation with the U.S. Soil Conservation Service and the Texas Agricultural Experiment Station.

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FOREWORD

The work reported in this monograph by Perry Glick was done from 1939 to 1949. How soil-conservation practices affect insect damage to cotton greatly interested F. C. Bishopp, assistant chief of the U.S. Department of Agriculture's (USDA) Bureau of Entomology and Plant Quarantine, and P. C. Annand, chief of the Bureau of Entomology and Plant Quarantine, who initiated and encouraged the study reported here. J. B. Pope, agriculturist, USDA, suggested that the study be conducted on the Blacklands Experimental Watershed near Waco, Tex. The study was primarily arranged by the Honorable W. R. Poage, Congressman of the 11th Texas District, where the Blacklands Experimental Watershed was located. The work was done under the direction of K. P. Ewing, then entomologist in charge of USDA's Cotton Insect Laboratory in Waco.

Though comprehensive and well done, the study was out of step with its times. Noninsecticidal studies of the insects and spiders that inhabit cotton agroecosystems were not particularly well received by reviewers, editors, administrators, or politicians during much of Perry Glick's career. So he often met resistance to publishing his elegant and detailed reports. Such a fate befell this important study. Rather than publish a vague and valueless summary of the data, Perry withdrew the manuscript. Time passed. With it, as the value of predators, parasites, and pathogens in pest control was elucidated, passed the nearly complete dominance of the proponents of chemical control as the sole means of managing cotton pests.

Recently, I found a review copy of the manuscript in the old USDA files housed at the Cotton Insect Research Laboratory at Texas A&M University. I saw at once that the study, though done between 30 and 40 years ago, was still enormously valuable, and I encouraged its publication. The details of the study are important for current and future researchers, so the data have been kept nearly intact. They are valuable not only for their picture of the relative differences in population densities attributable to conservation practices, but also as a checklist of species found on cotton in central Texas. Also, the relative abundance of these insects and spiders is important to those who would write a history of cotton production and pest management in the United States.

It is a tribute to the administrators and editors of Agricultural Research Service to agree to publish this long-overdue but timely manuscript. Long after short-term chemical studies on control of cotton pests are forgotten, Perry Glick's ecological studies on the spatial and temporal distribution of insects will still be valuable. At a time when most entomologists were jumping on the insecticidal bandwagon, Perry continued his ecological studies of insects that inhabit cottonfields. His research took a great deal of courage, not only to get data published over the objections of a few powerful people but also at the risk of bodily harm—his classic studies using airplanes to capture insects in the air were dangerous, since the vintage aircraft were flown in dif-

ferent kinds of not always favorable weather and even at night. Perry's publications have been widely cited and are currently being actively reviewed because of renewed interest in insect migration. His research has been honored by his election as a fellow of The Explorers Club of New York and as a fellow of the Royal Entomological Society of London.

WINFIELD STERLING, *Professor*
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PUBLISHER'S PREFACE

By and large, no attempt has been made to update this paper, originally written in 1951 (see Foreword). So the reader should approach the work as though it had actually been published in 1951. References will be available only in libraries. Predictions about the future should be regarded as the predictions of 1951, not 1982. But taxonomy and scientific names of plants and arthropods have been updated and are accurate for 1982.

ABSTRACT

Studies of arthropod abundance and insect damage to cotton as affected by cultural practices were conducted on an area of about 243 ha at the Blacklands Experimental Watershed near Waco, Tex. Detailed arthropod records were taken from 1939 to 1942, when conventional farming methods were used throughout, and during 1943, 1944, and 1947–49, when conventional methods were compared to improved cultural ones. Also during the period of these studies, a correlation was observed between the number of bollworm, *Heliothis zea* (Boddie), eggs on the cotton and the number of exit holes in the corn.

Before the cultural practices were implemented, the abundance of injurious insects affecting crops in general was much greater than that of entomophagous forms. By 1948, or 5 years after the cultural practices had been implemented, the entomophagous forms had increased from 14% to 83%. Where few insecticide treatments were used, the entomophagous forms were apparently able to increase continuously. Index terms: arthropod populations, cotton, cotton insects, cultural control (insects), insect populations, integrated pest management. *Address communications to Perry A. Glick, c/o the Cotton Insects Research Unit, Agricultural Research Service, P.O. Box 1033, Brownsville, Tex. 78520.*

INTRODUCTION

Cultural control practices are an integral part of contemporary systems for integrated pest management of insects. Better varieties of crops; insect, weed, and disease management; fertilizer or optimization; and other improved farming practices together with soil and water conservation have resulted in sustained, acceptable yields and more long-term profitable agriculture.

With expected population increase and heavier demands for food and fiber crops for domestic consumption and export, the yield per hectare must be even greater in the future. Possibly, the greatest hope lies in conservation and efficient use of water for irrigation. Further research will undoubtedly discover better methods of soil improvement, crop production, and preservation. Improved soil and water conservation practices produce higher yields as a result of providing more favorable plant-growing conditions.

The establishment of a larger Federal soil-conservation laboratory and station near Waco, Tex., in 1937 provided an ideal situation for determining how these new conditions affect the entomophagous and injurious insect population. In the spring of 1939, a cooperative project was set up by the U.S. Department of Agriculture's Bureau of Entomology and Plant Quarantine, its Soil Conservation Service, and the Texas Agricultural Experiment Station for studying insect damage to cotton with reference to soil-conservation practices. These studies were conducted from June 1939 until 1949, with an interruption of 2 years, 1945 and 1946.

Location

The laboratory and field station known as the Blacklands Experimental Watershed is located 29.6 km southeast of Waco, near Riesel, Tex. The general area is known as the Blacklands or the Blackland Prairies and comprises some 3,640,000 ha extending southwesterly from the Red River boundary of Texas to the Rio Grande Plain a few kilometers northeast of San Antonio (U.S. Department of Agriculture 1942). The experimental area in which the laboratory is located is about the center of the main Blackland Prairie in Mc-

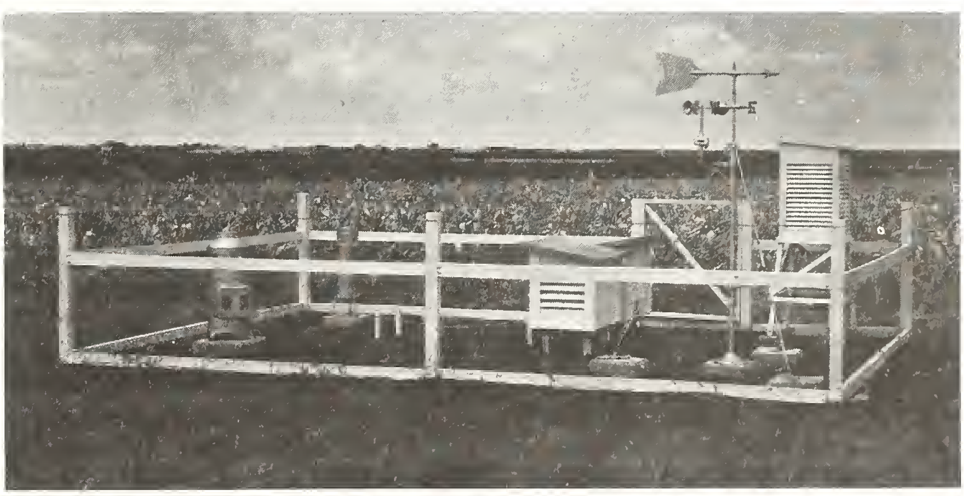

Figure 1.—Rain gages, anemometer, soil thermograph, and instrument shelters located at one of the field stations on the Blacklands Experimental Watershed.

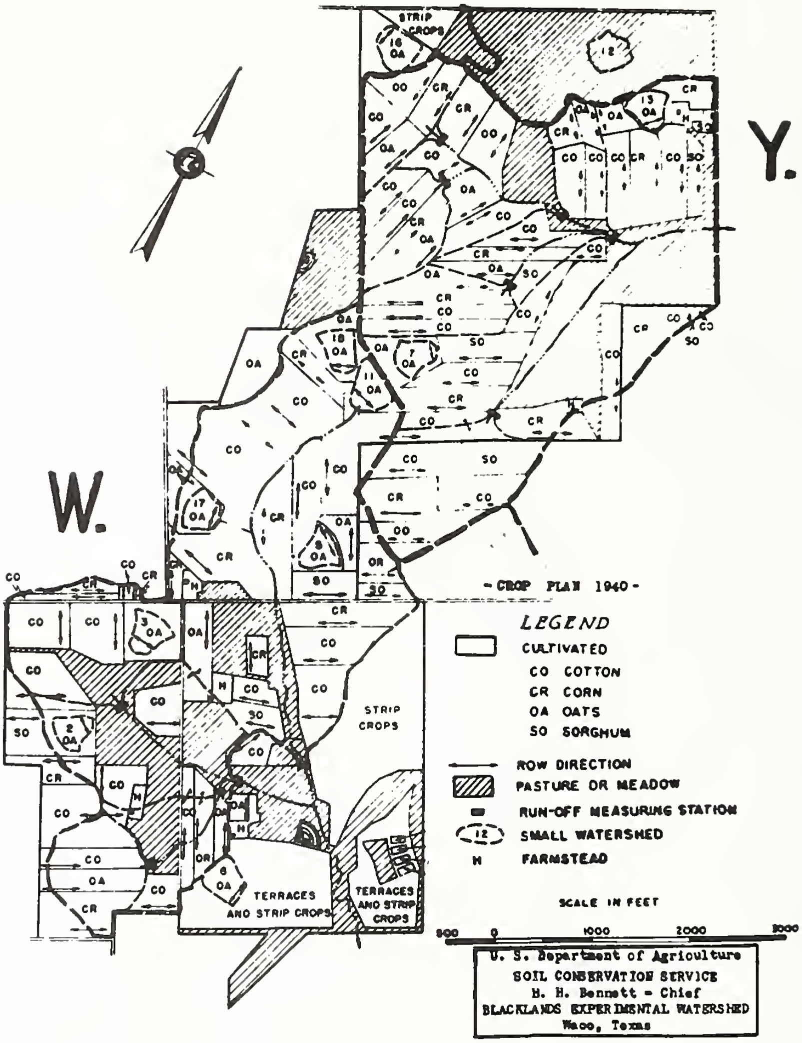

FIGURE 2.—Crop plan for 1940, Blacklands Experimental Watershed, representing the Y and W areas with two areas of 121 ha each, before conservation practices were introduced.

Lennan and Falls Counties, covering 2,570 ha, of which 340 ha are on land purchased by the Federal Government.

CLIMATE

The climate is characterized by long, hot summers and short, mild winters. The average yearly rainfall is 89–102 cm, with over one-third occurring during the period of April to June, but this may vary considerably. The mean annual temperature at the laboratory is 19° C. The winter temperatures vary widely with sudden changes, often accompanied by freezing temperatures and occasional snow. The growing season averages about 248 days. The prevailing wind direction is south from March through October and north from November through February.

SOILS

The soils of the experimental watershed belong mostly to the Houston, Wilson, and Crockett series. The watershed is characterized by rather deep soils, particularly of the Houston series, including Houston Black clay gravelly phase and Houston Black clay over chalk. A more detailed soil description is given in the discussion of the effect of soil types on the boll weevil population.

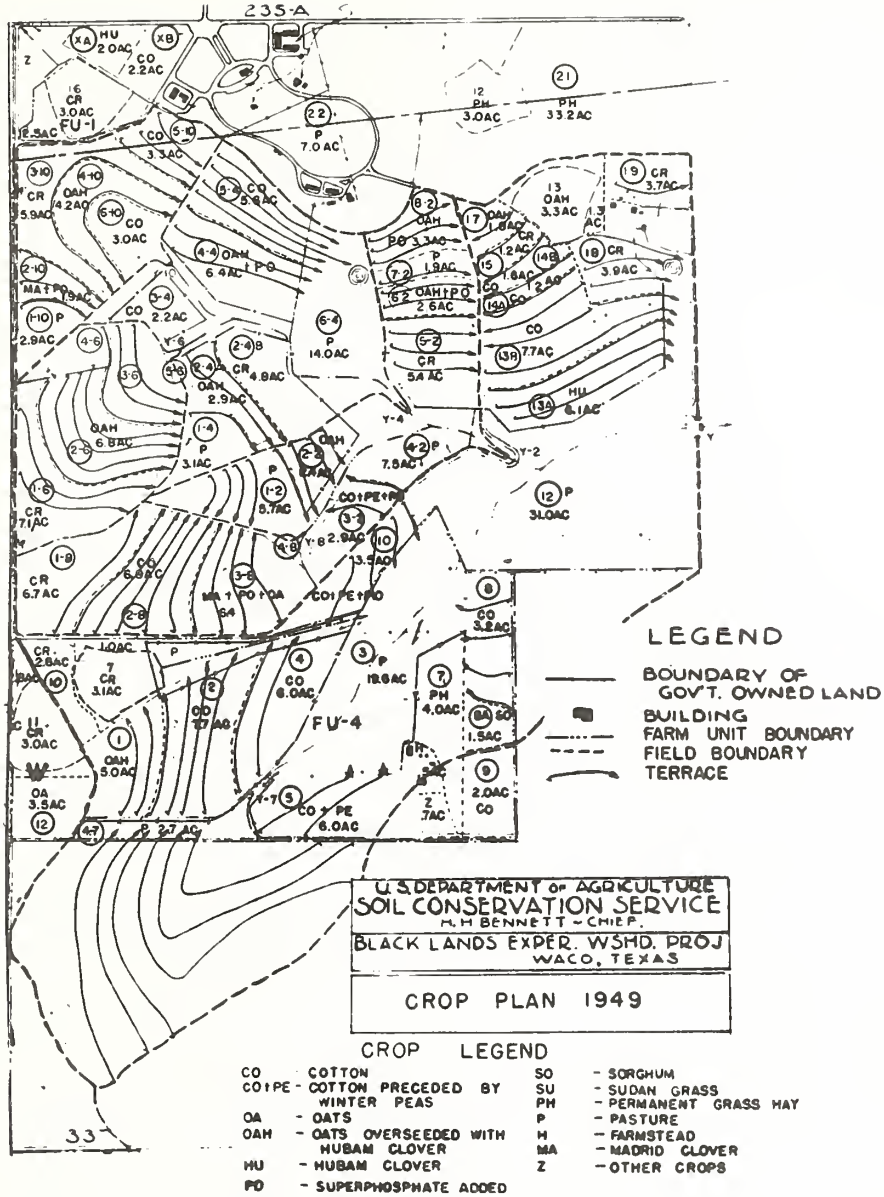

FIGURE 3.—Crop plan for 1949, Blacklands Experimental Watershed, representing the Y area after the new cultural practices were introduced.

WATERSHED CHARACTERISTICS AND OPERATION

This Blacklands Experimental Watershed Laboratory was designed to make a long-range study of the effect of erosion control practices and land use (1) upon the conservation of water for agricultural purposes and (2) upon the control of floods that destroy crops and damage soil fertility on agricultural bottom lands. It was also designed to study the rates of runoff and soil erosion from rains of various amounts and intensities on agricultural areas ranging in size from small watersheds to those covering 2,000–2,400 ha. The experimental watershed is also used for an intensive study of soil erosion and soil chemistry. Meteorological instruments were installed both at the main laboratory and at a number of field locations throughout the watershed so that hydrological data could be obtained (fig. 1).

The Government-owned land is divided into

Table 1.—Data collected on the more important species of insect pests in the cottonfields of the Y and W areas, 1939–44 and 1947–49

Year and area	Average No. thrips per plant	Squares injured by bollworms (%)	Bolls injured by bollworms (%)	No. flea-hoppers per 100 terminals	Squares punctured by boll weevils (%)	Cotton killed by root rot (%)	Estimated No. bolls per acre
	Conventional farm practices						
1939							
Y area		0.61	1.81	13.60	4.53	30.00	60,820
W area		.60	1.85	8.44	3.56	40.00	48,642
1940							
Y area	4.55	1.06	1.89	9.95	13.08	36.30	39,212
W area	5.43	.03	1.03	12.60	11.33	51.90	32,791
1941							
Y area	1.00	12.78	5.72	1.08	9.41	13.60	47,671
W area	4.92	8.28	2.44	1.77	6.64	36.60	39,312
1942							
Y area	1.06	2.11	0.83	3.10	8.50	11.20	50,602
W area	1.61	1.90	.45	6.20	8.20	27.20	40,954
Averages for 1939–42:							
Y area	2.20	4.14	2.56	6.93	8.88	22.80	47,076
W area	3.99	2.70	1.44	7.25	7.43	38.90	40,424
	Improved cultural practices, Y area[1]						
1943							
Y area	3.30	2.10	1.30	3.42	0.87	30.00	46,262
W area	5.90	2.00	1.20	11.39	1.10	60.00	36,494
1944							
Y area	1.90	.60	.06	4.54	1.65	3.29	44,463
W area	3.10	.90	.15	18.50	4.87	28.84	44,675
1947							
Y area	6.95	.17	.25	4.45	1.43	3.69	59,605
W area	4.98	.38	.90	11.80	4.70	10.40	45,085
1948							
Y area	12.80	1.05	1.98	4.30	7.47	6.59	77,495
W area	13.92	.38	1.46	7.99	8.97	33.54	53,014
1949							
Y area	2.21	2.11	3.36	17.88	4.06	33.80	55,103
W area	3.31	1.70	1.63	22.28	6.55	49.20	48,134
Averages for 1943–49:							
Y area	5.83	1.21	1.39	6.93	3.10	15.50	56,585
W area	6.24	1.07	1.11	14.39	5.24	36.4	45,480

[1]Conventional practices continued on the W area.

two cultivated areas of 121 ha each, with the remaining area in meadow, farm improvements, and drainage areas. These 121-ha areas, designated as Y and W, were farmed simultaneously for a number of years according to old farm or conventional practices. In 1943, new farming and soil-cultural practices were started in the Y area to run concurrently with the old, conventional practices on the W area.

Each of the two 121-ha divisions was divided into units that were farmed by individual tenants. The farm units were further divided into fields and were numbered on the land-use map (figs. 2 and 3). The farm-unit numbers were more or less constant from year to year, but the crops in the different fields were rotated according to schedule. There were four farm units, or tenants, in the Y area and five in the W area. In these farm units, fields of cotton and corn were selected for observation and infestation records.

Agriculture

The watershed contained some meadow grasses, principally bermudagrass, *Cynodon dactylon* (L.) Pers., and a little bluestem, *Schizachyrium scoparius* (Michx.) Nash. Along the drainage channels were brush, mostly mesquite (*Prosopis* spp.), and weeds. About four-fifths of the experimental area of the watershed was under cultivation. Nearly three-fourths of the cultivated land was in cotton, corn, oats, and sorghum.

Under the old farm practices, which were in operation during the first 4 years, approximately one-half the total cultivated land in the Y and W areas was planted to cotton, one-fourth to corn, and the remainder to oats, sorghum, and other small grains. Under the improved cultural practices, which were introduced in the Y area in 1943, approximately one-third of the total cultivated land was planted to cotton, one-third to corn or sorghum, and one-third to oats and legumes, or legumes alone. In addition, the amount of permanent grassland was increased from about 9% to 27% of the total area.

Program of Study

With the increased plantings of corn, small grain, and other erosion-control crops, there was offered a greater food supply for thrips, cutworms, armyworms, aphids, stink bugs, bollworms, and numerous other injurious insects. It was questioned whether this condition might not result in increased damage to the reduced areas of cotton. With a more succulent growth of cotton due to the cultural practices, would this condition provide a more attractive plant for cotton insects such as the cotton fleahopper, bollworm, and boll weevil, and possibly result in greater damage to cotton? On the other hand, certain soil and water conservation practices, such as strip cropping, could possibly lend protection against insects.

So that the many insect problems could be evaluated, a program of study was formulated to run for a period of 10 years or less, according to the progress made. The more important economic species of insects affecting cotton in the Blackland Experimental Watershed were considered, and detailed observations were made on them throughout the period of study (table 1).

Insect infestation counts were obtained from the same field or adjoining field in areas of Y and W for 4 years under prevailing conventional practices and for 5 years after the improved cultural farming practices were begun on area Y. The methods used in determining insect populations and infestations have been described (Glick and Ewing 1941). However, these will again be stated for the more important insects in the forthcoming discussion.

All farm practices were noted and studied, such as crop rotation, strip cropping, destruction of stalks, plowing, planting date, mowing pastures, roadside-weed destruction, legume cover crops, and occasional application of insecticides. The relation of insects to hydrological conditions was observed. Yield records were not used, as, in several years, records were not complete in many of the fields. Where crop yields were available, it was difficult to assign them to the direct effect of insect abundance since soil conservation practices entered the picture.

OBSERVATIONS ON THE MOST ECONOMICALLY IMPORTANT COTTON INSECTS

Cotton Fleahopper

The cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter), was the most abundant insect pest of cotton on the watershed, particularly in the W area. Among the factors that affected fleahopper abundance on cotton were the amount of rainfall, availability of wild host plants for egg deposition in the fall, time of hatching of nymphs the following spring, wind velocity and direction, and cultural practices.

Host plants

Cotton is not the preferred host plant of the cotton fleahopper. Thomas and Owen (1937), as well as the writer, observed that injury was worse within a cottonfield than on the margins. The injury was due more to the scarcity of other plants or weeds, such as primrose, horsemint, and croton, which the insect prefers, than to the insect's preference for cotton. Accordingly, at times when pastures and waste areas containing wild host plants are mowed in June, the adult fleahoppers may transfer to nearby cottonfields, thus increasing the abundance and damage. According to Reinhardt and Owen (1928), it is a good practice to destroy the wild host plants in order to reduce the early infestation in cotton.

Infestation

The fleahopper in both adult and nymphal stages may be carried by the winds from outlying areas and establish an infestation on whatever cotton is succulent and attractive. Some of the heaviest infestations observed on the watershed were in cleanly cultivated fields in which there was no evidence of wild host plants. The larger cottonfields usually had the heavier infestations. Apparently, the smaller fields afforded opportunity for the fleahoppers to seek wild host plants of their preference. Thomas and Owen (1937) concluded that, if the cotton fleahopper is given a chance to find its preferred hosts, it will have less need to feed on cotton.

Cotton fleahopper infestation records were begun when the cotton reached approximately the 4-leaf stage and were made by counting the adults and nymphs per 100 terminals. During the 4 years of study when the conventional farm practices were in use, the abundance of fleahoppers in the Y area was 5% less than in the W area. After the cultural farm practices were used in the Y area, the average abundance remained more or less constant; but, in the W area under the continued conventional farm practices, there was an appreciable increase in number of fleahoppers. The abundance in the Y area was low except for the years 1939 and 1949. However, in the W area, under conventional farm practices, the numbers were considerably greater, particularly from 1943 through 1949 (fig. 4). The occurrence of greater numbers in the W or conventional area may have some relation to the greater amount of root rot there; for, with the appreciable destruction of the cotton plants, there would follow a more concentrated population of nymphs and adults on the remaining living plants, which would in turn show a greater infestation (table 1). Root rot, caused by *Phymatotrichum omnivorum* (Shear) Dug, has been one of the major problems of the cotton farmer, especially on the watershed. In the Y area, which consisted of Houston Black clay, root rot was never so severe as in the W area. However, following initiation of the cultural practices in the Y area, there was a considerable reduction in the amount of root rot.

In the W area, there appeared to be a more concentrated infestation on living plants. One could find fleahopper nymphs on apparently healthy plants, and on the following day these same plants were wilting and dying from root rot. Jones (1941) considered that the factor that

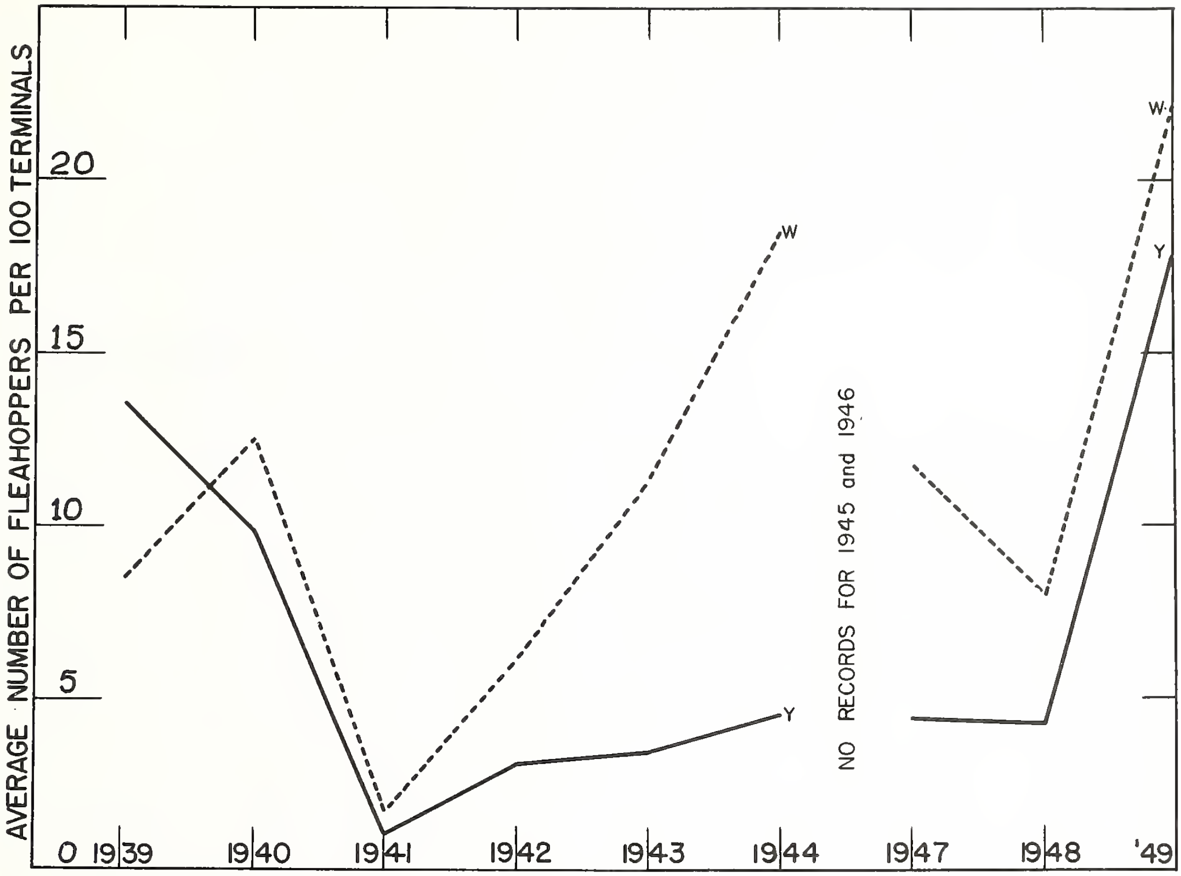

FIGURE 4.—The average number of fleahoppers collected per 100 terminals in selected cottonfields of the Y and W areas. From 1939 to 1942, conventional farm practices were followed. The years 1943 to 1949 included the period in which new cultural practices were employed.

determined the profit to be made from controlling insects on land where cotton dies from root rot is the yield from living plants regardless of the percentage of plants dying early in the season. He also believed that, if the yield from the living plants is sufficient for profitable cotton production and insects are damaging the crop, control measures should be used.

Ecological factors

Rainfall.—The amount of rainfall early in the spring or late in the fall affects fleahopper abundance. Gaines (1933) found that the numbers decreased during a dry period but increased following excessive rains in September, which caused goat weeds (*Croton* spp.) to start growing. As the preferred hosts dried up in the late spring and early summer, the numerous mature fleahoppers dispersed; and, because of their increased numbers, more of them reached cotton (Fletcher 1940). We normally observed increases in fleahopper populations following periods of rainfall.

Plant height.—During 9 years of study, the cotton plants in the W area (conventional farm practices) were higher than those in the Y area of the cultural farm practices. The heavier infestation in the W area appeared to be related to the increased plant height, since a reduction in fruiting forms resulted in increased vegetative growth of the plants.

Moisture content of plants.—With the new practices such as terracing and water conservation in operation, the cotton in the Y area was slightly more succulent, but the fleahopper did not reach the density observed in the W area.

Soil fertility.—In fields of the unimproved area (W), where no conservation practices were in

operation, the soil appeared to lack the nitrogen nutrient potential for the cotton plant. Cotton plants with less fruiting potential may have a relation to soil fertility and the size of the fleahopper population. The fleahopper damage did not increase in the Y area following cultural practices; but, in the W area, in which the conventional farm methods were continued, the fleahopper infestation was over 100% greater than in the cultural area of Y. Plants in the Y area where fleahopper damage occurred apparently were able to outgrow the effect by putting on additional terminals, while plants in the unimproved area of W with less fruiting potential were less able to replace the terminal growth damaged by the fleahoppers. Haseman (1950) considered that soil depleted of nitrogen and other essential nutrients would produce crops harboring larger and more destructive outbreaks of insect pests. He also believed that, to overcome this vicious circle, we should rebuild the soil fertility; in this way we would secure more effective insect control than by devoting so much effort to chemical warfare against crop scourges. The chinch bug, *Blissus leucopterus leucopterus* (Say), was one of the species considered by Haseman in his studies relating to nitrogen-depleted soil.

Cultural practices

During the 5-year period of observation, differences were evident in fleahopper abundance when cotton followed certain crops. A 20% increase occurred in fleahopper infestation when cotton followed sorghum; but when cotton followed oats, corn, or cotton, decreases were 29%, 63%, and 40%. The writer can offer no explanation for this phenomenon since sorghum is not a host plant. Conservation practices whereby cotton stalks are destroyed or plowed under after harvest effectively remove this source.

G. C. Decker of Illinois (personal communication) thinks that, while the observation of nitrogen-depleted soil and greater insect damage is valid for some species, it does not hold for others. He further comments that there are situations where the facts may be clouded. In the case of the chinch bug, it is probably true that it may do better on plants grown in a nitrogen-deficient soil. However, it is also very definitely true that chinch bugs try to avoid dense shade and therefore concentrate in fields where the stand of corn is thin or the plants decidedly weak. On the other hand, the European corn borer, *Ostrinia nubilalis* (Hübner), and a number of other pests prefer and will thrive best in the most vigorous growth.

With continued use of improved conservation practices including a crop rotation program, the soil will not become depleted of its essential mineral content. From the fact that fleahopper infestations did not increase after 5 years of improved farm practices, one would conclude that the succulent cotton was more resistant to the insect.

Bollworm

With the wide use of organic insecticides, bollworm, *Heliothis zea* (Boddie), numbers in many instances have increased, probably owing in part to the toxic effect of the chemicals on its predators and parasites. The bollworm did cause some damage to cotton on the watershed; and, on occasion during periods of high pest populations, insecticides were used in the new cultural practice areas. Some variance in infestation was shown in the areas where the old and new farm practices were in operation.

A definite correlation was found between the number of bollworm eggs in the cotton and the number of exit holes of this insect in corn. The records on corn were begun about 2 weeks after the corn began to silk, or when the first exit holes appeared in the ears. These records were made by counting the exit holes on 25 ears of corn at 8 points in a field. The cornfields inspected were adjoining or near the selected cottonfields of the Y and W areas. When nearly all the ears had exit holes, counts were discontinued.

The bollworm infestation records were made in cotton by inspecting 25 main-stem terminal buds at each of 8 points in a field for the presence of eggs, and by examining 25 squares and 25 bolls at each of 8 points in a field and recording the injured forms. The time of starting bollworm infestation records varied from year to year, but was usually about 2 weeks after the first emergence holes appeared in corn. From the records on corn, it could be determined when the maximum number of larvae were entering the soil for pupation. And it was possible to predict the approximate time of moth emergence and the appearance of eggs on cotton. The first eggs were found on cotton approximately 3 weeks from the time the first exit holes were recorded in corn.

In certain small areas where cotton was grown

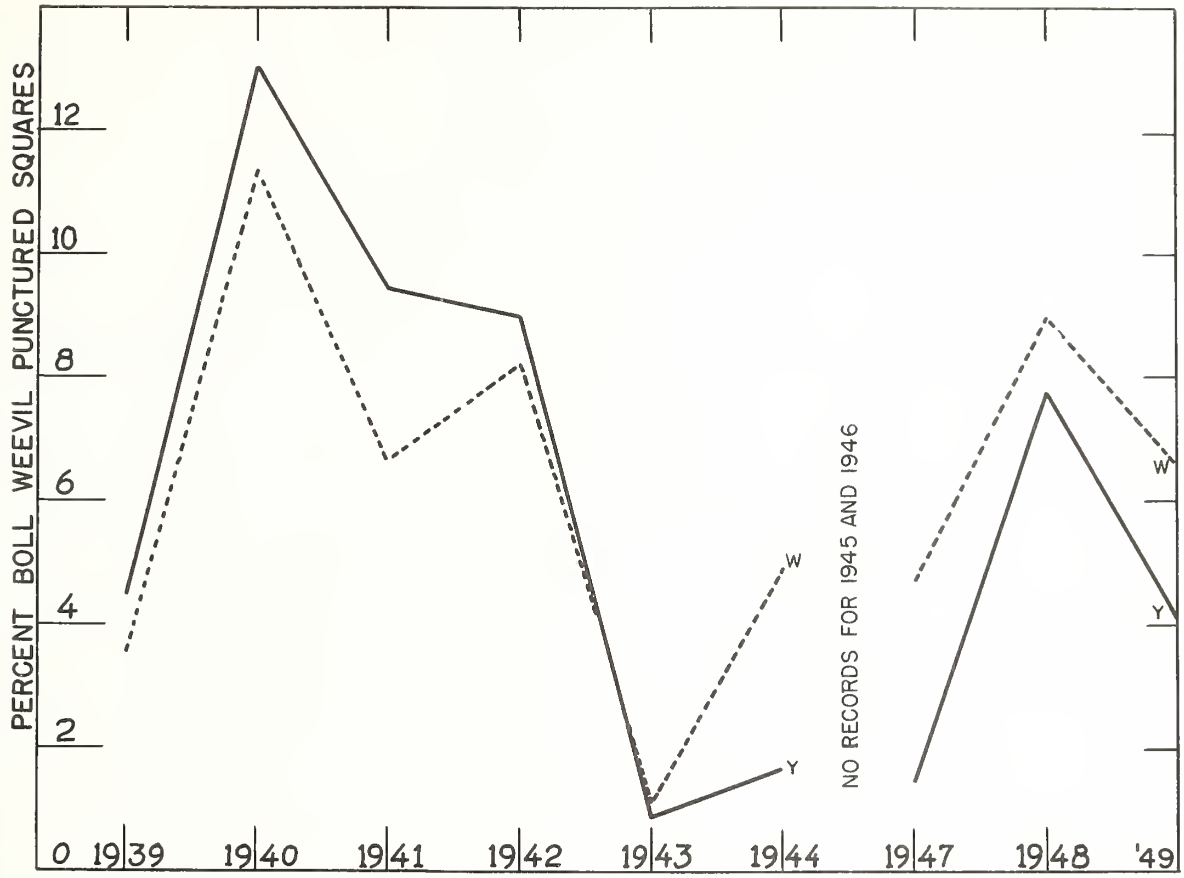

FIGURE 5.—The percentage of boll weevil punctured squares in the Y and W areas of selected cottonfields, showing the difference in infestation before and after conservation practices were introduced. From 1939 to 1942, the conventional farm practices were followed. The years 1943 to 1949 included the period in which cultural practices were in operation in area Y.

on terraced land, the cotton growing on terraces had more eggs than cotton growing between the terraces. On the terraces, the cotton was more succulent and the growth heavier. Fletcher (1941) found that the more succulent cotton was far more attractive to the moths.

The type of crop used in a rotation schedule may affect a bollworm infestation. Isley (1935) concluded that a succession of plantings of corn was favorable for the abundance of this insect and that legumes grown in combination with corn may extend the breeding season of the bollworm. In the crop-rotation program on the watershed, some differences were evident when cotton followed certain crops. There was an increase of 31% in bollworm-damaged bolls when cotton followed cotton. On the other hand, there was a reduction in infestation of 70% when cotton followed sorghum, 60% when it followed corn, and 57% when it followed oats. Since Barber and Dicke (1937) found that fall plowing was most advantageous in reducing moth emergence, it is recommended that cotton and corn be plowed under only in the fall.

Data (table 1) indicated an average of 12% reduction in bollworm-damaged squares and 20% reduction in damaged bolls when the new cultural practices were compared with the conventional practice areas for the years 1944, 1947, 1948, and 1949. Johns and Brown (1941) also found cultural practice helpful in reducing damage in cotton.

Boll Weevil

Infestation

Boll weevil, *Anthonomus grandis grandis* Boheman, damage to cotton on the Blacklands Experimental Watershed was never as important a

problem as it was in the bottom lands along the Brazos River. Only in 1940 was there recorded an appreciable infestation, and this was low as compared with other sections in McLennan and Falls Counties.

Boll weevil infestation was determined by collecting 25 squares at each of 8 points in a field and determining the percentage punctured. The record was started when the cotton averaged approximately five squares per plant. After the new cultural farm practices were introduced in the Y area, there was a reduction in square infestation by more than half, or from 8.9% (1939 to 1942) to 3.10% punctured squares (1943 to 1949). The type of crop that cotton followed appeared to affect the amount of boll weevil infestation in the improved conservation area. Cotton following cotton gave the least reduction in infestation, 41%, as calculated on the number of punctured squares. Cotton following oats showed a greater reduction, with still increased reductions when cotton followed corn or sorghum. These large reductions indicate what may happen in fields where cultural practices are used (fig. 5).

Ecological factors

Temperature, relative humidity, and rainfall, together with other ecological factors, limit the activities of the boll weevil. These weather conditions obviously affect the height of the cotton, moisture content of the plants, and temperature of the soil. These in turn affect the subsequent boll weevil population density and damage.

Seasonal temperature.—Sudden drops to freezing temperatures in either the early fall or late spring limit survival. Gaines (1951) concluded that correlations between winter temperatures and the numbers of weevils in cottonfields during May and June were significant. It has been shown that winters having low temperatures were followed by small field numbers of hibernating weevils whether abundance the previous year was great or small (Hixon and Sooter 1937). Sudden temperature drops in the early fall or winter in the Brazos Bottom (Waco area) usually caused higher mortality of weevils than even lower minimum temperatures in January or February after the weevils had become dormant. When weevils were still feeding on green cotton late in October, or even in November, and temperatures dropped 30 to 40 degrees within a few hours to a point below freezing, many were killed before they could enter hibernating quarters or were sufficiently sheltered.

On the watershed, the effects of low winter temperatures were more or less evident from year to year on the weevil population the following summer. From 1939 to 1942, the average minimum temperature for the 4 years was −9.7° C, with the lowest temperature occurring in 1940 in early January, accompanied with a foot of snow. Had this low temperature occurred in November or early December, a high mortality would have been expected. But a heavy snow remaining on the ground for more than a week appeared to protect the hibernating weevils. This is shown in the records in that the highest percentage of punctured squares (13.08%) was recorded on the project during the summer of 1940. However, lower winter temperatures were associated with appreciable reductions in weevil infestation for the following summers.

In 1943, a low of −18.9° C was recorded in January but without snow. The weevil infestation (table 2) dropped from a high of 8.5% punctured squares in the Y area in 1942 to a low of 0.87% punctured squares in 1943, or a reduction of some 90%. A low of −13.9° C was recorded in December 1943, with −13.3° C in January 1947, −11.7° C in January 1948, and −20° C in January 1949. The −20° C recorded in January 1949 was also accompanied with a foot of snow that remained on the ground over a week. There was shown a reduction of 45% in the amount of punctured squares in the Y area in 1949, as over the Y area in 1948. While snow undoubtedly protected the weevils in hibernation to some extent, the effect of the improved practices would appear to have contributed also in the decreased infestation. In the W area, with no conservation practices in operation, only a 12% reduction was shown.

Temperature and soil types.—The type or composition of the soil lends its importance to cotton production. The type of soil, whether sandy loam, rich bottom lands, or clay, will affect the succulence of the cotton plant and subsequent attractiveness to insects and resulting infestation. Soil temperature differs with each soil type, and the effect of these different temperatures may contribute to the numbers of boll weevils in a field (table 3). Although regression analysis of data presented in table 3 did not indicate a significant (0.05) correlation ($r = -0.309$), we observed light mortality of weevil larvae in squares on the

Table 2.—Boll weevil infestation as related to minimum winter temperatures recorded on the watershed, 1939–44 and 1947–49[1]

Year	Minimum temperature (°C)	Month and year recorded	Area	Squares punctured by boll weevils (%)
1939	−7.2	November 1938	Y	4.53
			W	3.56
1940	−15.0	January 1940	Y	13.08
			W	11.33
1941	−6.1	November 1940	Y	9.41
			W	6.64
1942	−10.6	January 1942	Y	8.50
			W	8.20
1943	−18.9	January 1943	Y	0.87
			W	1.10
1944	−13.9	December 1943	Y	1.65
			W	4.87
1947	−13.3	January 1947	Y	1.43
			W	4.70
1948	−11.7	January 1948	Y	7.47
			W	8.97
1949	−20.0	January 1949	Y	4.06
			W	6.55

[1]The minimum for 1945 was −2.2° C in Dec. 1944; the minimum for 1946 was −7.5° C in Dec. 1945. No record of boll weevil infestation is available for these years.

Table 3.—Amount of boll weevil infestation in relation to temperatures and soil formations of the Y and W areas, 1940–49

Year, area, and soil formation	Punctured squares (%)	Average maximum surface temperature (°C)	Average temperature 5 cm below surface (°C)
1940–42			
Y area:			
Houston Black clay	10.47	42.8	32.5
Houston Black clay, shallow phase over chalk	9.69	45.6	33.3
Houston Black clay, shallow phase	8.81	45.8	33.9
W area:			
Houston Black clay	8.29	42.8	33.9
Houston Black clay, shallow phase	8.03	42.2	33.3
Houston Black clay, gravelly phase	11.28	41.7	32.8
1943–49			
Y area:			
Houston Black clay	2.99	41.1	35.6
Houston Black clay, shallow phase over chalk	3.12	40.6	33.3
Houston Black clay, shallow phase	4.26	38.3	31.1
W area:			
Houston Black clay	4.39	45.6	35.6
Houston Black clay, shallow phase	5.55	43.3	33.3
Houston Black clay, gravelly phase	6.09	42.2	32.2

ground that were subjected to high temperatures resulting from direct sunlight. When the cotton is cultivated, these fallen squares are mostly turned under the surface soil and may be partially protected. Temperatures of from 35° C to as high as 43° C were frequently recorded 5.1 cm below the surface.

As previously stated, the predominant soil types in the Y area are Houston Black clay, Houston Black clay shallow phase over chalk, and a lesser amount of Houston Black clay shallow phase. The W area, where the conventional farm practices were continuous, contains no shallow phase over chalk, but contains from 16% to 39% Houston Black clay gravelly phase, a phase not present in the Y area where the new cultural practices were introduced.

Rainfall.—Boll weevils are affected by the amount of rainfall, especially when the cotton is in the square or early boll stage. Heavy damage is usually indicative of a wet summer. Hot, dry summers are detrimental to the development of the boll weevil (Hyslop 1941). Fenton and Hixon (1935) found that a severe drought checked an early infestation so that practically no damage was done. Smith and Young (1936) found a positive correlation between the number of weevils caught on a field screen and the number of days with 0.8 cm or more of rainfall. According to Isley (1932), relative humidity during the summer is the most important factor in the survival of immature weevils, and summer drought is the most frequent cause for potential outbreaks failing to materialize. Bolls carry the immature stages through an unfavorable season.

On the watershed, the effect of rainfall upon weevil populations was somewhat apparent (table 4). In 1940, 1941, and 1942 the rainfall was heavier in June than in July and August. Thus, the rain came when the cotton was in the square stage with a few early bolls, and accordingly the weevil damage increased during June and dropped off during July and August. In 1943, 1944, and 1947, most of the rain fell in May, with very little during the rest of the summer. The numbers of boll weevils during these years were much less. In 1949, rain was heaviest in July, and infestation for that year was also lighter. It appears that the greatest boll weevil damage occurred in June on the watershed, when a greater amount of rain was recorded.

Cotton root-rot damage appeared to be heavier when the rainfall was greater in the early spring months (table 4). When the root-rot damage was less, more cotton was available for weevil infestation, and the infestation was less concentrated. There appeared to be little relation between the height of the cotton plants and percentage of punctured squares.

Other Injurious Cotton Insects

The cotton aphid, *Aphis gossypii* Glover, was unimportant as a cotton pest on the Blacklands Experimental Watershed. In most years, the numbers were too light to record adequately. The cotton aphid often becomes very damaging to cotton in the bottom lands. According to Gaines (1951), the increased aphid population in a cottonfield furnishes a preferred food for the beneficial insects, which in turn allows a higher percentage of bollworm eggs and young worms to escape destruction. This is what may have happened in part on the watershed; for, with the small aphid density, the beneficial forms focused their attacks on the injurious cotton insects and caused the continued decrease in the injurious insects.

The variegated cutworm, *Peridroma saucia* (Hübner), and the yellowstriped armyworm, *Spodoptera ornithogalli* (Guenée), were occasionally found, but at no time was the stand of cotton affected.

Various species of pentatomids were observed and collected, and they often became sufficiently abundant to be of economic importance on the watershed. The species most prevalent in the fields were the redshouldered plant bug, *Thyanta custator* (Fabricius), and brown stink bug, *Euschistus servus* (Say). After certain leguminous crops were cut, *T. custator* was more abundant in the nearby cottonfields on the watershed. Indeed, the southern green stink bug, *Nezara viridula* (Linnaeus), and the spined soldier bug, *Podisus maculiventris* (Say), were occasionally seen feeding on young lepidopterous larvae.

The rapid plant bug, *Adelphocoris rapidus* (Say), contributed its share of damage to cottonfields on the watershed. After new cultural farm practices were in operation, it increased in about equal numbers in both the Y and W areas. This increase was probably due to the cover crops that were introduced with the new practices as the plant bugs were always abundant in them.

The flower thrips, *Frankliniella tritici* (Fitch),

Table 4.—Boll weevil infestation and cotton root rot as related to rainfall amount from May to August each year, 1939-44 and 1947-49, on selected cottonfields of the Y and W areas

Year and area	Rainfall (cm)				Total rainfall May to Aug. (cm)	Squares punctured by boll weevils (%)	Cotton killed by root rot (%)
	May	June	July	Aug.			
	Conventional farm practices						
1939							
Y area	12.4	7.0	0.8	5.7	25.9	4.53	30.00
W area	12.0	7.0	0.7	5.6	25.4	3.56	40.00
1940							
Y area	4.3	16.7	4.5	7.8	33.8	13.08	36.30
W area	4.9	17.9	5.3	5.4	33.4	11.33	51.90
1941							
Y area	12.3	17.3	8.9	3.5	42.0	9.41	13.60
W area	13.1	16.9	7.7	3.8	41.5	6.64	36.60
1942							
Y area	10.8	20.1	1.8	2.6	35.3	8.50	11.20
W area	12.0	18.7	2.2	2.5	35.3	8.20	27.20
Averages for 1939-42:							
Y area ..	13.3	15.3	4.0	4.9	34.3	8.88	22.80
W area ..	10.05	15.1	4.0	4.3	34.0	7.43	38.90
	Improved cultural practices, Y area[1]						
1943							
Y area	12.8	6.6	4.0	0.7	24.1	0.87	30.00
W area	11.8	5.0	4.0	0.7	21.4	1.10	60.00
1944							
Y area	31.7	4.0	5.0	3.8	44.5	1.65	3.29
W area	33.8	3.4	3.4	3.4	43.9	4.87	28.84
1947							
Y area	10.9	0.9	2.0	3.5	17.3	1.43	3.69
W area	10.6	1.5	1.6	4.6	18.3	4.70	10.40
1948							
Y area	14.0	3.5	3.2	1.6	22.3	7.47	6.59
W area	12.5	1.6	3.3	3.8	21.1	8.97	33.54
1949							
Y area	2.9	12.4	13.2	4.0	32.6	4.06	33.80
W area	2.7	11.6	12.4	4.5	31.2	6.55	49.20
Averages for 1943-49:							
Y area ..	14.4	5.5	5.5	2.7	28.1	3.10	15.50
W area ..	14.2	4.6	4.9	4.1	27.8	5.24	36.40

[1]Conventional practices continued on the W area.

causes damage to cotton from the seedling stage and until it starts blooming. In the watershed, it affected cotton each spring, delaying growth and often injuring or killing the young plants. Thrips counts were started when the cotton reached the 4-leaf stage and were made on 20 plants pulled at random in widely distributed areas over a field. Thrips were not included in the sweepings detailed in tables 6–9. After the cultural practices had been in operation, the number of thrips increased 165% in the Y area and 56% in the W area. After the legume cover crops—hubam, Madrid clover, and Austrian winter peas (rough pea or Caley pea), *Lathyrus hirsutus* Linnaeus, were introduced as a conservation practice in 1945, the thrips population increased. When the legumes were cut, the thrips transferred their activities to nearby cottonfields.

The loss of seed cotton caused by thrips may often be severe. There are fewer bolls per plant, and they are smaller and delayed in opening. When there is a heavy growth of weeds and grass in pastures, fence rows, and roadsides, particularly if the weeds are in bloom, thrips are usually abundant. Fletcher and Gaines (1939) noted greater thrips injury near the south side of a field, which they concluded was due to two factors: the field adjacent on the south was overgrown with weeds and grass having a large thrips population, and the prevailing wind was from the south. On the watershed, thrips damage at times appeared to be similar to fleahopper damage, as the young squares were similarly blasted and the terminal buds turned brown. As the plants increased in height, thrips damage was usually found.

Cotton leafworm, *Alabama argillacea* (Hübner), damage on the watershed was severe in 1939. In the following 2 years, the damage continued to be a factor, as much of the cotton was defoliated. From 1942 to 1944 and from 1947 to 1949 there were few or no leafworms.

OTHER CULTURAL PRACTICES

I have discussed the influence of various cultural practices on infestation by specific insects: for example, the influence of crop rotation; land topography; and the interrelationship of soil type, fertility, and cultural practices on insect populations. Other farm practices, such as strip farming, destruction of stalks, plowing, clean culture, planting date, cutting over pastures, roadside-weed destruction, and legume cover crops, also influence insect infestations. The relation of the various economic species of insects to hydrological conditions and farm practices was observed and noted, although the insecticide angle was not considered. In the setup of this study, control with insecticides was not to be used. In McLellan and Falls Counties, in which the watershed area lies, more than 75% of the cotton area is out of the bottom-land area. Insecticide studies on cotton insects have been mostly centered in the bottom-land area where infestation is usually heavier. The insect records taken in the upland cottonfields of the watershed are perhaps more representative of the two counties than had they been taken in the bottom-land area.

Strip Farming

When the insect and conservation studies began in 1939, numerous fields where strip farming was practiced were available outside the Blacklands Experimental Watershed. Records were also taken from these fields until the end of the 1943 season (fig. 6). When a strip-farming program was first introduced in 1935 and 1936 in McLennan and adjoining counties, it became an important factor in farm development. Later, however, strip farming was not considered feasible in this Texas area and accordingly was modified to a block-field crop-rotation program.

Figure 6.—Panorama of strip cropping showing oat strips on future terrace sites. Note the uniformity of the gently rolling terrain that is characteristic of the watershed. (Source: U.S. Soil Conservation Service.)

When block-field crop rotation has became established, it is doubtful if the farmer, particularly in the Southwest, will return to strip farming. Narrow-contour strip cropping in itself no longer can offer a solution in the soil-erosion program.

With the extensive use of leguminous crops such as hubam clover, Austrian winter peas, sweetclover, and soybeans, new insect problems have arisen. Some insect pests have transferred their attacks to these crops, often causing considerable damage. According to Bishopp (1938), certain destructive insects may be favored by strip farming if the crops are not carefully selected and insect relations kept clearly in mind.

Strip farming with leguminous crops also has had a tendency to increase insect damage. It has been reported that cutworms have caused serious damage as a result of strip farming, particularly with legumes and corn or other row crops and small grains. It has even been demonstrated that strip farming using other than leguminous crops such as small grains, corn, or sorghum greatly increases the hazard from chinch bugs, and materially increases the cost of their control (Annand 1940).

The belief that strip cropping lends certain protection against injury to cotton from insects, particularly fleahoppers, seems to hold true of light-to-medium infestations, but not where the infestation is heavy. Thomas and Owen (1937) have stated that a tall crop, such as grain sorghums or corn, planted adjacent to or in strips through a cottonfield may cause these migrating fleahoppers to rise higher while in flight and possibly to be carried farther by winds.

Records were made in the strip-cropping areas for the cotton fleahopper population outside of the Y and W areas. Eight fields were selected each year when available. The fields were divided so that in one series the cotton was stripped with tall crops, such as corn and sorghum, and in another series with low crops, such as oats and clover. Whenever possible, two fields in each series were selected with rows running in the direction of the wind and two fields running crosswise to the prevailing wind. Each field had three strips of cotton in which fleahopper records were made at weekly intervals. The 2d, 6th, 10th, and 14th rows from the outside toward the center of each strip were selected for the records. Twenty-five terminal buds at each of two points on the selected rows were inspected for fleahoppers. Data obtained from this long-term experiment did not indicate any consistent relationship between fleahopper size and height of the strip crops or row direction in relation to wind direction.

Fletcher (1940) observed that in a cottonfield in Texas nearly all weeds are either killed by frequent cultivation or by chopping, whereas cornfields are rarely cultivated after the first week in June. On the watershed, croton continues to come up all summer, even as late as October. From these weeds, the adult fleahoppers enter the adjacent strips of cotton, or the nymphs may be carried by the wind.

Sweepings were made in weeds and grass adjacent to or near cotton rows running either with or crosswise to the prevailing wind. From 1941 through 1943, most injurious insects were collected in weeds near tall crops. Nearly half the specimens belonging to the family Miridae that were collected were fleahoppers. Most were taken in patches of croton growing near an oatfield adjacent to cotton rows running crosswise to the wind.

Pentatomids were found mostly in the weed association bordering low crops such as hubam clover and oats, with adjacent cotton rows running with the direction of the wind. Fewer pentatomids were taken in weeds bordering tall crops such as corn and sorghum, where the cotton rows ran crosswise to the wind.

Cultivation

Tower and Gardner (1946) state that fall plowing or early spring tillage of stubble strips will destroy many grasshopper eggs by exposing them to freezing and drying or by burying them so deeply that the hoppers cannot reach the surface after hatching. A few species such as the lesser migratory grasshopper, *Melanoplus mexicanus* (Saussure), prefer stubble wheatfields in the fall. In the Blacklands areas of Texas, there is little chance for the eggs to be frozen. Plowing of soil may contribute to grasshopper control as many eggs occurring in the Blacklands area are thus destroyed. John L. Landrum and the late W. J. Spicer of the Grasshopper Control Project (unpublished data) reported that the eggs of the range species have been desiccated to powder-dry condition and yet survived. J. C. Bridwell observed that insects in a desert emerged in abundance after a sudden rain following years of drought (Glick 1939).

Many of the cottonfields were completely defoliated by grasshoppers along the marginal rows. It would appear that the greater number of marginal rows in strip farming increases the availability of the cotton to grasshoppers, especially if they are near pastures. Grass used in strips will induce grasshopper infestation. Frequent cultivation of fallow strips in land where strip farming is practiced retards egg deposition, particularly of the differential grasshopper, *Melanoplus differentialis* (Thomas), as this species does not prefer a freshly tilled soil, but deposits its eggs in pastures or waste places. Accordingly, clean culture practices will tend to eliminate this grasshopper.

There are probably more species of insects on cotton than on any other cultivated crop. Cotton not only affords food, but foliage concealment. Annand (1948) considered that more than 100 species attack the cotton crop in one way or another. This was probably a conservative estimate, for each season there are recorded additional species feeding on some part of the plant. It was of special interest to determine the overall insect fauna in the cottonfields and the seasonal abundance of the species observed. According to Isley (1932), such studies may be of additional value in determining the causes favoring the unusually rapid multiplication of a given species that culminates in an outbreak. The survey was started by making weekly sweepings with a 41-cm sweeping net with 25 sweeps at each of 8 points in the cottonfields of the Y and W areas.

In 1942, before cultural practices were started in the Y area, of the total insects collected only 7% were entomophagous. When the improved practices were introduced in 1943, the beneficial insects increased to 14%; in 1944 to 36%; in 1947 to 51%; in 1948 to 63%; and in 1949, a slight decrease, 60% beneficial insects. The numbers of insects collected per 100 sweeps are sufficiently high to permit the use of percentages to evaluate the effects (fig. 7, table 5).

With the Y and W areas adjacent in a restricted locality, it is possible that the effect of the cultural practices in the Y area would lend some effect to the conventional practices in the W area. With the considerable increase in entomophagous insects in the Y or cultural area, some increase was shown in the entomophagous abundance in the W area.

While the entomophagous insects showed a continuous increase in the Y area from 1943 to 1949, when the recommended cultural farm practices were in operation, there was also an appreciable reduction of the phytophage abundance. This observation is based on the number of insects taken per 100 sweeps, and includes all species that may be of economic importance, such as plant feeders. During the survey, many hundreds of entomophagous forms and phytophages were collected, representing eight orders of insects and one order of spiders.

Table 5.—Relative abundance of entomophagous and injurious insects collected at weekly intervals in cottonfields of the Y area, 1942–44 and 1947–49[1]

Year	Total No. sweeps	No. entomophagous insects (average per 100 sweeps)	No. injurious insects (average per 100 sweeps)	Entomophagous insects (%)
1942	1,800	1.61	21.40	7
1943	1,800	1.50	9.33	14
1944	2,700	20.52	36.04	36
1947	1,800	15.78	15.11	51
1948	3,600	22.14	13.22	63
1949	4,500	43.89	29.58	60

[1]Conventional farm practices used in 1942, and new cultural practices used 1943–44 and 1947–49.

Entomophagous Arthropods in Cotton

Six orders of insects and one order of spiders were represented by the entomophagous arthropods found in the cottonfield sweepings (table 6).

Araneida.—Spiders aid in the control of many injurious insects. Kagan (1943), while assisting the writer in the insect observations on the watershed in 1939, observed species of spiders feeding on nymphs and adults of the rapid plant bug and the cotton fleahopper, on nymphs of the cotton aphid, and on larvae of the bollworm moth.

Coleoptera.—Among the entomophagous families represented in Coleoptera were the Anthicidae, Cantharidae, Carabidae, Cleridae, Coccinellidae, Lathridiidae, Melyridae, Nitidulidae, and Phalacridae. The cantharid species *Chauliog-*

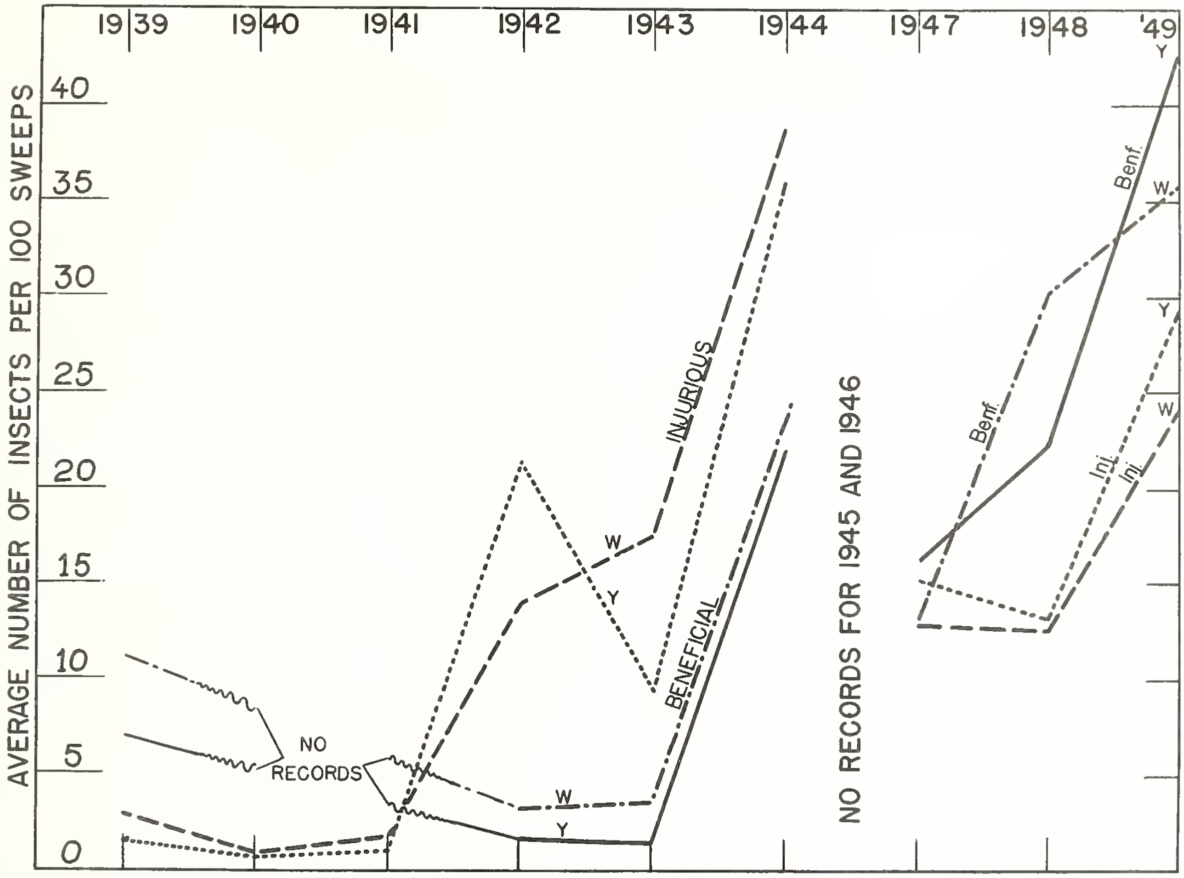

FIGURE 7.—The average number of entomophagous and injurious insects collected per 100 sweeps on selected cottonfields of the Y and W areas on the Blacklands Experimental Watershed. This represents what may happen in a locality where cultural practices are used and insecticide applications are infrequent. Note that the entomophagous arthropods greatly increased in both areas after the conservation practices had been in operation for 7 years.

nathus marginatus Fabricius was collected. It has previously been reported feeding on some lepidopterous larvae (Dozier et al. 1932). The carabids represented were *Callida decora* (Fabricius) and *Lebia calliope* Bates. The clerid of special interest taken on cotton was *Phyllobaenus pubescens* (LeConte), as it is reported to be a parasite upon the larvae of the boll weevil. In the Coccinellidae are found the most important predaceous Coleoptera. Lady beetles contribute considerably to the reduction of eggs, larvae, or nymphs of many of the more important injurious insects. The species commonly collected in the watershed and appearing most abundantly were *Cycloneda sanguinea* (Linnaeus), *Hippodamia convergens* Guérin-Méneville, *Olla v-nigrum* Mulsant, and *Scymnus* spp. Of the Melyridae, *Collops balteatus* LeConte and *C. vittatus* (Say) were collected. *C. quadrimaculatus* was also found but not during the years reported in table 6. *Collops* spp. were reported feeding on bollworm eggs and young larvae (Ewing and Ivy 1943).

Diptera.—In the Diptera, Asilidae were represented by four predaceous species that contribute directly to the natural biological control of many insect pests. The species found in the collections were *Atomosia puella* (Wiedemann), *Diogmites discolor* Loew, *D. symmachus* Loew, and *Lampria rubriventris* (Macquart). Syrphidae were represented by the species *Mesograpta marginata* (Say) and *M. polita* (Say). Syrphid larvae feed mostly on aphids and often assist considerably in reducing an aphid population. The family Tachinidae includes some important parasites, the larvae being parasitic mostly within lepidop-

(*Continued on page 22.*)

Table 6.—Entomophagous arthropods collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49

Entomophagous species collected	Average No. collected per 100 sweeps[1]	
	Area Y	Area W
Araneida, undetermined spp.	7.03	8.53
Coleoptera:		
Anthicidae, *Notoxus monodon* Fabricius	.006	.007
Cantharidae:		
Belotus abdominalis (LeConte)	.125	.035
Belotus sp.	.007	.028
Chauliognathus marginatus Fabricius	.090	.021
Carabidae:		
Callida decora (Fabricius)	.007	0
Lebia calliope Bates	.319	.006
Lebia spp.	0	.006
Lebia viridis Say	.007	.006
Cleridae, *Phyllobaenus pubescens* (LeConte)	0	.056
Coccinellidae:		
Ceratomegilla fuscilabris (Mulsant)	.305	.222
Cycloneda sanguinea (Linnaeus)	0	.118
Exochomus sp.	.007	.006
Hippodamia convergens Guérin-Méneville	1.82	1.93
Hyperaspis frimbriolata Melsheimer	.14	.006
Hyperaspis undulata (Say)	0	.028
Olla v-nigrum Mulsant	.076	.019
Psyllobora sp.	.028	.076
Psyllobora taedata LeConte	.139	.076
Scymnus creperus Mulsant	2.030	2.22
Scymnus loewii Mulsant	1.54	1.48
Scymnus sp.	1.28	1.00
Undetermined spp.	.014	0
Lathridiidae:		
Corticaria sp.	.011	.007
Melanophthalma distinguenda Comolli	.874	.87
Melyridae:		
Collops balteatus LeConte	.007	.006
Collops sp.	.21	.21
Collops vittatus (Say)	.007	.210
Nitidulidae, *Carpohilus* sp.	.011	.16
Phalacrididae, undetermined spp.	.597	.667
Staphylinidae, undetermined spp.	0	.006
Diptera:		
Asilidae:		
Atomosia puella (Wiedemann)	.007	0
Diogmites discolor Loew	.014	0
Diogmites symmachus Loew	.014	.006
Lampria rubiventris (Macquart)	.014	0
Dolichopodidae:		
Chrysotus picticornis Loew	.069	.208
Chrysotus sp.	.014	.006
Mycetophilidae, undetermined spp.	.042	.035
Syrphidae:		
Mesograpta marginata (Say)	.076	.013
Mesograpta polita (Say)	.014	.006
Undetermined spp.		
Adults	.313	.111
Larvae	.007	.013

See footnote at end of table.

Table 6.—Entomophagous arthropods collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps[1]	
	Area Y	Area W
Diptera—Continued:		
Tachinidae:		
Archytas incertus (Macquart)	0	0.006
Hemithrixion oestriforme Brauer & Bergenstamm	0	.13
Hemiptera:		
Anthocoridae:		
Orius insidiosus (Say):		
Adults	2.830	2.19
Nymphs	.014	.13
Undetermined spp.	.014	.13
Lygaeidae:		
Geocoris punctipes (Say):		
Adults	.132	.208
Nymphs	.021	0
Geocoris ulginosus (Say)	.007	.035
Nabidae, *Nabis alternatus* Parshley:		
Adults	.097	.028
Nymphs	.007	.013
Phymatidae, *Phymata fasciata georgiensis* Melin	.014	0
Reduviidae:		
Arilus cristatus (Linnaeus)	.035	.076
Sinea confusa Caudell	.014	0
Zelus renardii Kolenati:		
Adults	.111	.326
Nymphs	.021	.049
Hymenoptera:		
Apidae, *Apis mellifera* Linnaeus	.063	.48
Braconidae:		
Agathirsia sp.	0	.006
Apanteles theclae Riley	.007	0
Bracon mellitor (Say)	.104	.361
Chelonus sp.	.007	0
Lysiphlebus testaceipes (Cresson)	.014	.013
Chalcididae:		
Brachymeria tegularis (Cresson)	0	.006
Dirhinis texanus (Ashmead)	.014	.013
Spilochalcis sp.	.007	.013
Cynipidae, *Trybliographa* sp.	.007	0
Eupelmidae, *Eupelmus* sp.	0	.006
Formicidae, undetermined spp.	2.47	1.08
Halictidae, *Agapostemon melliventris* Cresson	0	.006
Pteromalidae:		
Catolaccus aeneoviridis (Girault)	0	.006
Eucolinae spp.	.007	0
Halticoptera aenea (Walker)	0	.006
Zatropis tortricidis Crawford	.007	0
Scelionidae:		
Trimorus sp.	.028	0
Trimorus n. sp.	0	.035
Vespidae:		
Polistes sp.	.021	.021
Polistes fuscatus (Fabricius)	0	.013
Undetermined spp.	1.25	1.02

See footnote at end of table.

Table 6.—Entomophagous arthropods collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps[1]	
	Area Y	Area W
Neuroptera; Chrysopidae, *Chrysopa* spp.:		
Adults	0.76	0.63
Larvae	.14	.35
Orthoptera; Mantidae, undetermined spp.	0	.006
Total of averages of entomophgous arthropods collected	25.26	25.87

[1]14,400 total sweeps taken in areas Y and W.

terous larvae. *Archytas incertus* (Macquart) and *Hemithrixion oestriforme* Brauer & Bergenstamm belonging to this family were collected. The latter is rare, but *A. incerta* is a well-known parasite in the bollworm, and adults were collected frequently in the sweepings.

Hemiptera.—Hemiptera contains some of the most important of the entomophagous insects. They occurred in both the Y and W areas. The more important effective ones belonged to the families Anthocoridae, Lygaeidae, Nabidae, Pentatomidae, and Reduviidae, including the species *Arilus cristatus* (Linnaeus), *Geocoris punctipes* (Say), *G. ulginosus* (Say), *Nabis alternatus* Parshley, *Orius insidiosus* (Say), *Sinea confusa* Caudell, and *Zelus renardii* Kolenati. *O. insidiosus* is one of the most valuable predators, for there are many reports of its consuming bollworm eggs. This incidence of *O. insidiosus* feeding on bollworm eggs was also observed at times by the writer. A few of the pentatomids are important as predators, although the family is predominantly phytophagous. *Podisus maculiventris* (Say) and *Thyanta custator* (Fabricius) often feed on the early stages of lepidopterous larvae.

Hymenoptera.—A large number of entomophagous species belong to Hymenoptera. They were represented by, among others, the Braconidae, Chalcididae, Cynipidae, Halictidae, Pteromalidae, and Vespidae. Of the Braconidae, *Bracon mellitor* (Say) is a well-known parasite of the boll weevil. The braconid *Lysiphlebus testaceipes* (Cresson) was collected in large numbers, and it is an important parasite of the cotton aphid. The family Chalcididae is widely distributed and includes many important primary and secondary parasites. The species taken in the sweepings on cotton include *Brachymeria tegularis* (Cresson), *Dirhinus texanus* (Ashmead), and *Spilochalcis* spp. The Pteromalidae include many important parasites and hyperparasites. The species represented were *Catolaccus aeneoviridis* (Girault), *Halticoptera aenea* (Walker), and *Zatropis tortricidis* Crawford. The family Vespidae was represented by one species, *Polistes fuscatus* (Fabricius), taken in the sweepings. Although this wasp is often a nuisance to cottonpickers as it frequently builds its nest in the cotton plants, it is also an important predator as it attacks small bollworms and leafworms. Only a few species of the Cynipidae and Halictidae were taken, and, though parasitic, they were not collected in sufficient numbers to be considered important as affecting injurious cotton insects.

Neuroptera.—Neuroptera was represented by the lacewing flies, mostly *Chrysopa oculata* Say. These are very beneficial.

Orthoptera.—Of the Orthoptera, Mantidae was the only family represented that is entomophagous. Although not abundant, they are highly predaceous.

Of the total entomophagous arthropods collected, a greater number belonged to the Coleoptera. Spiders were next in numbers taken. The injurious Hemiptera were generally more abundant in the collections than the beneficial Hemiptera as the latter are mostly predaceous on insects of other orders, and their role in the reduction of injurious Hemiptera is accordingly less important than that of other insects.

Not all the species of injurious insects listed in table 7 have been reported to attack cotton. Since corn, sorghum, legumes, oats, and grasses were considered in the crop-rotation program on the watershed, any insects observed attacking these crops or that have been reported as injurious are listed. However, in the following discussion, only those species are mentioned that are known to attack cotton or that were observed by the writer to cause injury to cotton though not previously reported.

Coleoptera.—The injurious Coleoptera comprised 22% of the total injurious insects taken in the Y area, and 41% in the W area (1942–49). In the Y area, 66% of the species of Coleoptera were beneficial and 34% were injurious (see tables 6 and 7). The species were much the same for both areas. Although many are of economic importance, not all are injurious to cotton. The most important families of injurious Coleoptera are Chrysomelidae, Curculionidae, Elateridae, and Meloidae.

No one species of Chrysomelidae is known to cause appreciable damage to cotton, although as a whole the chrysomelids do feed to some extent on the blossoms and the succulent leaves and terminals. The corn flea beetle, *Chaetocnema pulicaria* Melsheimer, is often seen on the cotton plant and was noted at times eating small holes in the leaves as well as the petals of the blossoms.

Of the injurious Coleoptera collected, 25% in the Y area belonged to the family Curculionidae, and 11% in the W area. Although numerous boll weevils were collected, it is difficult to estimate abundance since the adults mostly remain in the bracts of the squares or blossoms and are not easily swept from the plant by the net. *Compsus auricephalus* (Say) has been observed by the writer to do some damage to cotton by eating the leaves of the seedlings and the terminal buds of the larger plants. Folsum (1936a) recorded similar damage to cotton. Specimens of this beetle were often taken in the sweepings.

The elaterids include some important pests of cotton, particularly species of wireworms attacking the roots. Adults of *Conoderus lividus* (De Geer), *C. vespertinus* (Fabricius), and *Glyphonyx praecox* (Erichson) were taken frequently in the sweepings, and were often seen on cotton. *C. vespertinus* is often a pest of corn as well as tobacco and causes much damage to cotton. It occasionally caused some loss in the stand of corn on the watershed.

The meloids were represented by several species. They occur usually in the blossoms, feeding on either the pollen or the petals. Although the larvae are beneficial, several species of adults are reported to attack cotton (Little and Martin 1941a, 1941b, 1941c, 1941d). Those taken were *Epicauta callosa* LeConte, *E. candidata* Champion, *E. pennsylvanica* (De Gerr), *E. atrata* (Fabricius), *E. uniforma* Werner, and *Tetraonyx fulva* LeConte.

Hemiptera.—Of the 3,660 injurious insects collected in the Y area throughout the period of study, 36% were Hemiptera; and of 3,610 collected in the W area, 39% were Hemiptera. Most insects of this order are phytophagous, although many are predaceous. The predaceous Hemiptera species do not attack the injurious Hemiptera as readily as they attack insects of other orders. The families with injurious species are Berytidae, Coreidae, Cydnidae, Lygaeidae, Miridae, Pentatomidae, Piesmatidae, and Tingidae.

The injurious coreids taken were *Arhyssus lateralis* (Say), *A. parvicornis* (Signoret), *Chariesterus antennator* (Fabricius), *Harmostes reflexulus* (Say), *Liorhyssus hyalinus* (Fabricius), and *Niesthrea sidae* (Fabricius). The coreids are predominantly phytophagous, although a few species are predatory. All species taken in the sweepings on cotton are known to attack it, although the amount of damage they cause is limited and seldom severe. *A. lateralis* appeared most frequently in the collections.

The injurious species of Cydnidae taken were *Corimelaena marginella* Dallas and *Galgupha carinata* McAtee & Malloch. At times, both species were commonly seen in cotton, particularly *G. carinata*, and were occasionally seen feeding on the young succulent leaves.

Of the Lygaeidae, California tortoiseshell bug, *Nysius californica* (Boisduval), and false chinch bug, *N. raphanus* Howard, are reported to attack cotton in the southern San Joaquin Valley in California (Essig and Hoskins 1944). However, no injury was noted on the watershed from these lygaeids. The chinch bug is often seen on cotton, but its presence is undoubtedly incidental. C. D. Smith (unpublished data) recorded it on cotton but made no reference to any injury it may cause.

The mirids comprise the more important species

(*Continued on page 28.*)

Table 7.—Injurious insects collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Coleoptera:		
Bruchidae, *Mimosestes protractus* (Horn)	0.042	0
Buprestidae, *Agrilus lacustris* LeConte	.011	0
Cantharidae, *Silis* sp.	.111	.014
Cerambycidae, *Ataxia hubbardi* Fisher	0	.007
Chrysomelidae:		
Acalymma vittata (Fabricius)	.006	.007
Chaetocnema pulicaria Melsheimer	1.422	1.44
Deloyala guttata (Olivier)	.006	0
Diabrotica undecimpunctata undecimpunctata Mannerheim	.206	0
Diachus auratus (Fabricius)	.011	.028
Epitrix hirtipennis (Melsheimer)	0	.014
Epitrix fasciata Blatchley	.111	0
Glyptina brunnea Horn	.027	0
Glyptina pallicornis Schaeffer	0	.06
Longitarsus varicornis Suffrian	.017	0
Pachybrachis bivittatus (Say)	0	.15
Pachybrachis diversus Fallen	.044	0
Pachybrachis immaculatus Jacoby	.594	.49
Phyllotreta pusilla Horn	.022	.17
Systena brunnea Horn	0	.14
Typophorus nigritus viridicyaneus (Crotch)	.011	.12
Zygogramma sp.	.006	0
Cryptophagidae, *Cryptophagus* sp.	0	.007
Curculionidae:		
Anacentrinus deplanatus (Casey)	.017	.007
Anthonomus grandis grandis Boheman	.444	.826
Compsus auricephalus (Say)	.006	.007
Cylindrocopturus adspersus (LeConte)	.006	0
Cylindrocopturus nanulus (LeConte)	.022	.007
Perigaster sp.	.011	0
Semicronyx sp.	.027	.C6
Undetermined spp.	.066	.090
Elateridae:		
Conoderus lividus (De Geer)	0	.007
Conoderus vespertinus (Fabricius)	0	.007
Glyphonyx praecox (Erichson)	.117	.160
Undetermined spp.	2.10	.200
Meloidae:		
Epicauta atrata (Fabricius)	.011	.007
Epicauta callosa LeConte	.181	.10
Epicauta candidata Champion	0	.007
Epicauta pennsylvanica (De Geer)	.006	.007
Epicauta sp.	.189	.80
Epicauta uniforma Werner	0	.007
Tetraonyx fulva LeConte	.006	.007
Tetraonyx sp.	.006	0
Melyridae, undetermined spp.	0	.007
Mordellidae, undetermined spp.	.056	.11
Undetermined spp.	0.311	3.78

See footnotes at end of table.

Table 7.—Injurious insects collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera:		
Berytidae:		
Jalysus spinosus (Say)	0.027	0.007
Jalysus wickhami Van Duzee	.011	.007
Coreidae:		
Arhyssus lateralis (Say)	.039	.028
Arhyssus parvicornis (Signoret)	.011	.007
Arhyssus sp.	.027	.014
Chariesterus antennator (Fabricius)	.006	.007
Exptochiomera fuscicornis (Stal)	.011	0
Harmostes reflexulus (Say)	.006	.014
Leptoglossus phyllopus (Linnaeus)	0	.007
Liorhyssus hyalinus (Fabricius)	.011	.007
Niesthrea sidae (Fabricius)	.022	.021
Undetermined spp.:		
Adults	0	.021
Nymphs	.011	0
Cydnidae:		
Corimelaena marginella Dallas	.072	.06
Galgupha carinata McAtee & Malloch	0	.007
Lygaeidae:		
Blissus leucopterus leucopterus (Say)	.006	.05
Nysius californica (Boisduval)	.017	.007
Nysius raphanus Howard	.039	.011
Ortholomus scolopax (Say)	.006	.042
Ortholomus sp.	.022	0
Taylorilygus pallidulus (Blanchard)	.022	.007
Miridae:		
Adelphocoris rapidus (Say):		
Adults	3.25	2.21
Nymphs	.594	.65
Lygus lineolaris (Palisot de Beauvois)	.006	.007
Polymerus basalis (Reuter)	0	.007
Pseudatomoscelis seriatus (Reuter):		
Adults	3.284	4.26
Nymphs	.133	.50
Reuteroscopus ornatus (Reuter)	.011	0
Rhinacloa forticornis Reuter	0	.007
Sixeonotus areolatus Knight	.006	0
Sixeonotus insignis Reuter	0	.014
Trigonotylus doddi (Distant)	.006	0
Trigonotylus pulcher Reuter	.017	0
Pentatomidae:		
Camirus porosus (Germar)	.006	0
Euschistus servus (Say)	.272	.065
Mecidea major Sailer	.006	0
Murgantia histrionica (Hahn)	.002	.014
Nezara viridula (Linnaeus)	.027	.139
Oebalus pugnax (Fabricius):		
Adults	.063	.011
Nymphs	.006	0

See footnotes at end of table.

Table 7.—Injurious insects collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera—Continued:		
Pentatomidae—Continued:		
Podisus acutissimus Stal	0.006	0.028
Podisus maculiventris (Say)	.022	.011
Thyanta custator (Fabricius)	.227	.216
Undetermined spp.:		
Adults	.022	.046
Nymphs	.017	.245
Piesmatidae, *Piesma cinereum* (Say)	0	.007
Tingidae, *Gargaphia solani* Heidemann	0	.007
Undetermined spp.	0	.014
Homoptera:		
Acanaloniidae, *Acanalonia bivittata* (Say)	.006	0
Cercopidae:		
Clastoptera xanthocephala Germar	0	.014
Lepyronia gibbosa Ball	0	.014
Undetermined spp.	.022	0
Cicadellidae:		
Aceratagalla uhleri (Van Duzee)	.066	.014
Agallia constricta Van Duzee	.05	.08
Balclutha neglecta (DeLong & Davidson)	0	.014
Chlorotettix viridis Van Duzee	.044	.05
Cuerna costalis (Fabricius)	.188	.146
Draeculacephala portola Ball	.017	0
Empoasca abrupta DeLong	1.06	1.10
Empoasca fabae (Harris)	1.92	.09
Exitianus exitiosus (Uhler)	0	.007
Flexamia producta (Walker)	0	.007
Graphocephala versuta (Say)	.006	.007
Homalogisca coagulata (Say)	.011	.035
Macrosteles fascifrons (Stal)	.011	.007
Norvellina seminuda (Say)	0	.021
Oncometopia orbona (Fabricius)	.011	.049
Scaphytopius frontalis (Van Duzee)	0	.09
Scaphytopius irroratus (Van Duzee)	.172	.271
Stirellus bicolor (Van Duzee)	.011	.021
Texananus exultus (Uhler)	.006	0
Undetermined spp.:		
Adults	.272	.11
Nymphs	.217	.16
Xerophloea viridis (Fabricius)	.011	0
Cixiidae:		
Cixius stigmatus (Say)	0	.028
Oliarus aridus Ball	.372	.33
Oliarus concinnulus Fowler	.128	.05
Dictyopharidae, *Scolops pugens* (Germar)	.022	.014
Flatidae, *Metcalfa pruinosa* (Say)	0	.014
Fulgoridae:		
Dictyonissus griphus Uhler	.011	0
Undetermined spp.	.011	0

See footnotes at end of table.

Table 7.—Injurious insects collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Homoptera—Continued:		
Membracidae:		
Campylenchia latipes (Say)	0.089	0.035
Entylia sinuata (Fabricius)	.011	.007
Micrutalis calva (Say)	0	.007
Spissistilus festinus (Say)	.292	.111
Stictocephala bisonia Kopp & Yonke	.033	0
Vanduzea laeta var. *segmentata* (Fowler)	.066	.007
Psyllidae:		
Craspedolepta minuta (Caldwell)	.006	0
Pachypsylla celtidisgemma Riley	0	.028
Pachypsylla celtidismamma (Riley)	.006	.007
Trioza diospyri (Ashmead)	0	.007
Lepidoptera:		
Ctenychidae:		
Heterocera, undetermined sp., adults	0	.028
Microlepidoptera, undetermined spp:		
Adults	.022	.014
Larvae	.066	0
Scisseps fulvicollis (Hübner)	.006	0
Lycaenidae:		
Lepidopterous larvae	.027	.04
Strymon melinus Hübner:		
Adults	.035	.014
Larvae	.20	0
Noctuidae:		
Alabama argillacea (Hübner):		
Adults	.042	.028
Larvae	.444	1.10
Pupae	.022	.040
Heliothis zea (Boddie):		
Adults	.144	.06
Larvae	.444	.49
Pyralidae:		
Achyra rantalis (Guenée)	.039	.05
Phalaenidae, undetermined sp.	.006	0
Orthoptera:		
Acrididae:		
Chortophaga viridifasciata (De Geer)	0	.007
Dissosteira carolina (Linnaeus)	0	.007
Hadrotettix trifasciata (Say)	.006	0
Hesperotettix speciosus Scudder	.002	.014
Melanoplus differentialis (Thomas):		
Adults	.161	.15
Nymphs	.004	0
Orphulella pelidna pelidna (Burmeister)	.011	0
Schistocerca americana (Drury)	0	.007
Blattidae, undetermined spp.	.006	0
Gryllacrididae; Gryllacridinae, undetermined sp.	0	.011
Gryllidae:		
Oecanthus nigricornis Walker	.035	.04
Oecanthus quadripunctatus Beutenmüller	.006	.014
Oecanthus sp.	.044	.011

See footnotes at end of table.

Table 7.—Injurious insects collected in selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Orthoptera—Continued:		
Tettigoniidae:		
Amblycorpha sp.	0.006	0.007
Arethaea sp.	0	.007
Conocephalus fasciatus (De Geer)	.006	0
Decticinae, undetermined spp.	.011	0
Grasshopper, undetermined spp.:		
Adults	.250	.12
Nymphs	.378	.39
Scudderia furcata Brunner von Wattenwyl	.027	0
Scudderia sp.	0	.014
Total of averages of injurious insects collected	129.17	187.20

[1]12,600 total sweeps taken in area Y.
[2]13,300 total sweeps taken in area W.

of Hemiptera and the same ones are known to be both predatory and beneficial. Among those collected were *Adelphocoris rapidus* (Say), *Lygus lineolaris* (Palisot de Beauvois), *Pseudatomoscelis seriatus* (Reuter), *Reuteroscopus ornatus* (Reuter), *Rhinacloa forticornis* Reuter, *Taylorilygus pallidulus* (Blanchard), *Trigonotylus doddi* (Distant), and *T. pulcher* Reuter. The species known to do serious damage to cotton are *A. rapidus* and *P. seriatus.* Occasionally, *T. pallidulus* and *R. forticornis* cause some damage.

The pentatomids collected were *Camirus porosus* (Germar), *Euschistus servus* (Say), *Mecidea major* Sailer, *Murgantia histrionica* (Hahn), *Nezara viridula* (Linnaeus), *Oebalus pugnax* (Fabricius), *Podisus acutissimus* Stal, *P. maculiventris* (Say), and *Thyanta custator* (Fabricius) (=*T. initator teste* Sailer). Of these, *E. servus* and *T. custator* were collected in greater numbers in the Y area, and *N. viridula, P. acutissimus,* and *T. custator* in the W area. Though *P. maculiventris* is also known to be an important predator of lepidopterous larvae, the nymphs were often observed feeding on cotton bolls.

Homoptera.—Species belonging to Homoptera are phytophagous. Many are serious pests and a few are definitely injurious to cotton. The families represented were Acanaloniidae, Cercopidae, Cicadellidae, Cixiidae, Dictyopharidae, Flatidae, Fulgoridae, Membracidae, and Psyllidae.

The cercopids collected were *Clastoptera xanthocephala* Germar and *Lepyronia gibbosa* Ball. These spittle insects or froghoppers were frequently found in cotton, and the nymphs have been observed on the cotton plants in a mass of foam feeding on the plant juices. However, the damage was probably negligible.

Cicadellidae, leafhoppers, are usually more or less abundant on cotton and undoubtedly contribute to the total damage to the cotton plant. Twenty or more species were taken. The most common were *Cuerna costalis* (Fabricius), *Empoasca abrupta* DeLong, *E. fabae* (Harris), *Graphocephala versuta* (Say), *Homalogisca coagulata* (Say), *Oncometopia orbona* (Fabricius), and *Scaphytopius irroratus* (Van Duzee). *E. abrupta* has been found in considerable numbers at times and undoubtedly causes appreciable damage to cotton. Although *E. fabae* contributes some damage to cotton, it has only occasionally been collected or seen in numbers comparable to *E. abrupta.*[1]

Damage to cotton by leafhoppers appears to be more important than is generally considered, as

[1]*E. fabae* and *E. abrupta* were tentatively determined by the writer. However, H. B. Cunningham of the Illinois Natural History Survey Division states that it is certain that both these species are present in the Waco area.

much of the general foliage damage is usually considered to be due either to these insects, to weather effects, or to plant disease. When leafhoppers appear in the sweepings in numbers far greater than any other cotton pest, it may be assumed that their damage is important. The leaves may become yellow, followed by drying, and often the cottonfield appears unhealthy.

Membracids are often seen on the cotton plant, and their presence has usually been disregarded. The species collected in the sweepings were *Campylenchia latipes* (Say), *Entylia sinuata* (Fabricius), *Micrutalis calva* (Say), *Spissistilus festinus* (Say), *Stictocephala bisonia* Kopp & Yonke, and *Vanduzea laeta* var. *segmentata* (Fowler). *S. festinus* has often been collected in considerable numbers on cotton, and there may be an association with a type of injury sometimes seen on the cotton stem and the characteristic injury produced on alfalfa. Ewing and McGarr (1933) found that *S. festinus* in cage experiments produced rings or feeding punctures around the petiole and stems, which often caused an abnormal growth; but no material injury to the cotton resulted, and final production was not affected. *E. sinuata* has been reported feeding on terminal shoots (Smith 1917). It was observed feeding on the terminal of cotton on the watershed.

The psyllids taken included *Craspedolepta minuta* (Caldwell), *Pachypsylla celtidisgemma* Riley, *P. celtidismamma* (Riley), and *Trioza diospyri* (Ashmead). Although some species are known to be very injurious to cotton in other countries, no injury from these insects was noted on the watershed.

Lepidoptera.—Lepidoptera contains some of the major pests of cotton. Two species of noctuids collected in large numbers were the bollworm and the cotton leafworm. Adults and larvae of the bollworm were collected throughout the summer for all 9 years. Records of leafworm moths occurring in the sweepings were not kept until 1942. The larvae were collected in greater numbers in 1942, 1943, and 1944. No infestation appeared on the watershed from 1947 and 1949. The cotton square borer, *Strymon melinus* (Hübner), was occasionally collected in the sweepings, although its actual damage to cotton on the watershed was of little importance. Garden webworms, *Achyra rantalis* (Guenée), were taken in the sweepings in both Y and W areas in 1949. At times, considerable damage was caused by this pyralid on the watershed, as some cotton plants were almost defoliated, the webs completely covering the plants.

Orthoptera.—A species of Orthoptera commonly taken was the differential grasshopper. Often the cotton was completely destroyed or defoliated, especially along the marginal rows of a field. Two species of tree crickets, *Oecanthus nigricornis* Walker and *O. quadripunctatus* Beutenmüller, were often taken. Tree crickets were commonly seen in the fields throughout the period of study, although not in sufficient numbers to cause definite injury to cotton at any given time. They are also predaceous on aphids (Little and Martin 1941a, 1941b, 1941c, 1941d).

INSECT SURVEY IN WEED AND GRASS ASSOCIATIONS

Weeds and grasses are a constant source of insects attacking cultivated crops. This was evident for the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), in Louisiana, for it was observed by the writer in great numbers on the common fleabane (*Erigeron*) transferring to cotton in sufficient numbers to cause considerable damage. On the other hand, the entomologist may promote clean cultivation to reduce insect infestation, but may overlook the fact that in these same areas a supply of entomophagous arthropods is also to be found that may offset any damage due to injurious insects. There are times, however, when the insect population may become so great that weeds and grass are destroyed. Metcalf and Flint (1932) recorded the writer's observation of the artichoke plume moth, *Platyptilia carduidactyla* (Riley), destroying 90% of the flower heads of pasture thistle in some localities.

There were occasions when insect damage on the watershed was attributed to the weeds as a source of the injurious insects transferring to cotton. This was evident for grasshoppers, cotton webworm moths, stinkbugs, fleahoppers, and thrips. Accordingly, it was important that a study be made to determine and evaluate this source of beneficial and injurious insect habitat and its relation to the selected cottonfields.

Entomophagous Arthropods in Weeds

During the period of this study, 10,960 entomophagous arthropods were taken in the weed and grass associations of the Y and W areas (table 8). There was little difference between the weed associations of the two areas. As several hundred species of entomophagous arthropods were collected, only the most important will be discussed. Many of the species also occur in cotton.

Araneida.—A total of 2,956 spiders of many families were collected in the two areas. Spiders are always present in weeds and contribute considerably to the reduction of injurious insects. Although they attack beneficial insects, they all benefit agriculturalists, especially cotton farmers, because they reduce cotton fleahopper nymphs and other mirids.

Coleoptera.—Coleoptera includes many of the most important predaceous insects. Among the families represented were Cantharidae, Carabidae, Cleridae, Coccinellidae, Lampyridae, Melyridae, and Phalacridae. The cantharid *Belotus abdominalis* (LeConte) was swept from goldenrod, where it commonly occurred. It was occasionally seen in cotton blossoms or on leaves of young cotton when aphids were present and was observed feeding on the aphids. The carabids frequently collected included *Lebia ornata* Say, *L. viridis* Say, and *L. vittata* (Fabricius). The common black ground beetle, *Harpalus caliginosus* (Fabricius), was also collected. It has been seen feeding on pupae and larvae of the boll weevil in fallen squares. Three species of clerids were taken: *Phyllobaenus knausi* (Wickham), *P. pubescens* (LeConte), and *P. scaber* (LeConte). The so-called checkered beetles include a number of predaceous species, the larvae feeding on various insects. According to Clausen (1940a, 1940b), *P. pubescens* appears to be parasitic upon the larvae of the boll weevil in its cell in the boll. There were 13 species of coccinellids taken in the sweepings on weeds. They were similar to those taken on cotton. *Scymnus* spp. and *Hippodamia convergens* Guérin-Méneville appeared more frequently than the other coccinellids. They apparently showed no preference as to the type of weeds or grass as long as aphids were present. Several species of lampyrids were collected on sunflowers, *Helianthus annuus.* Larvae of the firefly family are partly entomophagous with some evidence that they may feed on cutworms (Clausen 1940a, 1940b). Melyridae comprises some very important entomophagous insects. The species collected were *Collops balteatus* LeConte, *C. quadrimaculatus* (Fabricius), and *C.*

(*Continued on page 37.*)

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Araneida:		
Mimetidae, *Latrodectus mactans* (Fabricius)	0	0.007
Undetermined spp.	15.33	13.24
Coleoptera:		
Anthicidae, *Notoxus monodon* Fabricius	.023	.015
Cantharidae, *Belotus abdominalis* (LeConte)	.698	.451
Carabidae:		
Harpalus caliginosus (Fabricius)	0	.007
Lebia ornata Say	.008	.007
Lebia viridis Say	.016	.015
Lebia vittata (Fabricius)	.008	.007
Cleridae:		
Phyllobaenus knausi (Wickham)	0	.007
Phyllobaenus pubescens (LeConte)	.111	.158
Phyllobaenus scaber (LeConte)	.016	.015
Coccinellidae:		
Ceratomegilla fuscilabris (Mulsant)	.071	.098
Cycloneda munda (Say)	.016	0
Cycloneda sanguinea (Linnaeus)	.063	.060
Hippodamia convergens Guérin-Méneville	.389	.241
Hyperaspis frimbriolata Melsheimer	.230	.271
Hyperaspis sp., near *gemma* Casey	.008	.113
Hyperaspis undulata (Say)	.128	.165
Nephus intrusus (Horn)	.294	.037
Olla v-nigrum Mulsant	.008	.007
Psyllobora sp.	.151	.090
Psyllobora taedata LeConte	.032	.068
Scymnus creperus Mulsant	.278	.782
Scymnus loewii Mulsant	.444	.172
Scymnus spp.	1.785	1.256
Undetermined spp.:		
Adults	.071	.060
Larvae	.024	0
Cryptophagidae, *Cryptophagus* spp.	.016	0
Lampyridae, undetermined spp.	.032	0
Lathridiidae, *Melanophthalma distinguenda* Comolli	.579	.624
Melyridae:		
Collops balteatus LeConte	.032	.067
Collops quadrimaculatus (Fabricius)	0	.007
Collops spp.	.032	.090
Collops vittatus (Say)	0	.007
Undetermined spp.	.111	.316
Phalacridae, undetermined spp.	9.98	3.97
Staphylinidae, undetermined spp.	.016	.007
Diptera:		
Asilidae:		
Atomosia puella (Weidemann)	.008	.015
Efferia spp.	0	.007
Lampria rubriventris (Macquart)	.016	.045
Bombyliidae, *Bombylius variosus* Fabricius	.008	.007
Dolichopodidae, *Chrysotus picticornis* Loew	.008	0

See footnotes at end of table.

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Diptera—Continued:		
Drosophilidae:		
Scaptomyza adusta (Loew)	0.032	0.007
Scaptomyza graminum (Fallen)	.016	.007
Sarcophagidae:		
Senotainia rufiventris (Coquillett)	.008	0
Spathid exia dunningii (Coquillett)	.008	0
Syrphidae:		
Mesograpta marginata (Say)	.024	0
Mesograpta polita (Say)	.127	.053
Undetermined spp.:		
Adults	.841	.037
Larvae	0	.180
Tachinidae:		
Archytas incertus (Macquart)	0	.007
Archytas marmoratus (Townsend)	.024	0
Cylindrimyia fumipennis (Bigot)	.008	0
Euphorocera floridensis Townsend	0	.007
Euthera bicolor Coquillett	.008	0
Euthera spp.	.016	.037
Hemithrixion oestriforme Brauer & Bergenstamm	.016	.007
Lespesia archippivora (Riley)	.008	0
Leucostoma spp.	.206	.068
Phoranthella punctigera (Townsend)	.024	0
Undetermined spp.	.111	0
Undetermined spp.	1.421	1.060
Hemiptera:		
Anthocoridae, *Orius insidiosus* (Say):		
Adults	1.79	.662
Nymphs	0	.301
Lygaeidae:		
Geocoris pallens Stal	.008	.015
Geocoris punctipes (Say):		
Adults	.079	.18
Nymphs	.040	0
Geocoris ulginosus (Say)	0	.016
Hypogeocoris imperalis (Distant)	.016	0
Hypogeocoris spp.	.040	0
Nabidae:		
Nabis alternatus Parshley:		
Adults	.151	.067
Nymphs	.032	.030
Nabis capsiformis (Germar)	0	.007
Undetermined spp.	0	.549
Phymatidae:		
Phymata fasciata georgiensis Melin	.024	0
Phymata n. spp.	.024	.015
Reduviidae:		
Arilus cristatus (Linnaeus)	.056	.133
Atrachelus cinereus (Linnaeus)	.008	.007

See footnotes at end of table.

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera—Continued:		
Reduviidae—Continued:		
Sinea confusa Caudell:		
Adults	0.055	0.048
Nymphs	.032	.083
Sinea diadema (Fabricius)	.032	.048
Sinea spinipes (Fabricius), nymphs	.032	.015
Undetermined spp., nymphs	.087	.037
Zelus renardii Kolenati:		
Adults	.079	.143
Nymphs	.016	.015
Zelus socius Uhler	.045	.015
Hymenoptera:		
Andrenidae:		
Anthophora spp.	0	.007
Perdita spp.	0	.007
Undetermined spp.	.738	.226
Apidae:		
Apis mellifera Linnaeus	.148	.406
Svastra obliqua oblique (Say)	0	.007
Bethylidae:		
Anisepyris spp.	.008	0
Epyris spp.	0	.007
Parasierola cellularis (Say)	.016	.007
Pristocera armifera (Say)	0	.007
Bombidae, *Bombus* spp.	0	.007
Braconidae:		
Agathirsia spp.	.016	0
Apanteles terminalis Gahan	0	.015
Apanteles theclae Riley	0	.007
Bracon gelechiae Ashmead	016	.007
Bracon mellitor (Say)	.045	.015
Bracon platynotae (Cushman)	0	0
Bracon spp.	.008	.007
Callihormius spp.	0	.007
Chelonus insularis Cresson	.32	.068
Crassomicrodus divisus (Cresson)	.008	0
Cremnops nigrosternum (Morrison)	0	.007
Cremnops vulgaris (Cresson)	.008	0
Hecabolus, undetermined spp.	.008	0
Heterospilus prosopidis Viereck	0	.053
Microplitis feltiae Muesebeck	0	.023
Opius spp.	0	.007
Orgilus gelechiae (Ashmead)	0	.007
Protomicroplitis garmani Ashmead	0	.007
Vipio rugator (Say)	0	.007

See footnotes at end of table.

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hymenoptera—Continued:		
Chalcidoidea:		
Acmo-polynema bifasciatipenne (Girault)	0	0.015
Anastatus reduvii (Howard)	0	.007
Anastatus semiflavidus Gahan	0	.007
Anastatus spp.	.008	0
Brachymeria hammari (Crawford)	.008	.015
Brachymeria n. spp.	0	.007
Brachymeria ovata (Say)	0	.007
Brachymeria tegularis (Cresson)	0	.007
Bubekia sp.	0	.007
Catolaccus aeneoviridis (Girault)	.008	.037
Catolaccus hunteri Crawford	0	.037
Cecatosmicra debilis (Say)	.008	0
Chrysopophagus compressicornis Ashmead	.008	.045
Diaulinopsis callichroma Crawford	0	.015
Diglyphus websteri (Crawford)	0	.007
Dirhinus texanus (Ashmead)	.016	.015
Discodes spp. (*Eneyritidae*)	.008	.007
Elasmus setosiscutellatus Crawford	.008	.007
Encyrtidae, undetermined spp.	.008	.015
Eudecatoma spp.	0	.007
Eulophus brevicapitus (Cook and Davis)	.008	.037
Eupelmus allynii (Fench)	.008	.007
Eupelmus auratus Ashmead	.016	.023
Eupelmus cyaniceps Ashmead	.008	.007
Eupelmus popa Girault	.008	.556
Euplectrus comstockii Howard	.008	.007
Euplectrus plathypenae Howard	0	.007
Eurytoma n. spp.	.008	.007
Eurytoma spp.	.016	.037
Eurytoma tylodermatis Ashmead	0	.015
Eurytomidae, undetermined spp.	.088	.045
Gonatocerus spp.	.008	.015
Habrocutus spp.	.008	0
Habrocytus purpureiventris (Ashmead)	.008	.030
Habrocytus spp.	0	.007
Haltichella n. spp.	.008	.023
Haltichella xanticles (Walker)	.008	.007
Halticoptera aenea (Walker)	.008	.007
Halticoptera spp.	0	.007
Herbertia spp.	0	.015
Homalotylus terminalis (Say)	0	.015
Horsimenus toxanus Crawford	0	.023
Mesopolobus spp.	.008	0
Metadontia amoena (Say)	0	.007
Microdontomerus anthonomi (Crawford)	.008	.052
Neocatolaccus tylodermae (Ashmead)	.008	.007
Notanisomorpha meromyzae Gahan	0	.007
Ooencyrtus spp.	0	.015
Pachyneuron albutius (Walker)	.016	.015

See footnotes at end of table.

Table 8.—**Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued**

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hymenoptera—Continued:		
Chalcidoidea—Continued:		
Paraorias n. spp.	0	0.007
Perilampus anomocerus Crawford	0	.007
Perilampus carinifrons Crawford	0	.007
Perilampus chrysopae Crawford	.008	.083
Perilampus fulvicornis Ashmead	.198	.451
Perilampus hyalinus Say	.008	.030
Pseudocatoeaccus spp.	.008	0
Psilocera rufipes (Ashmead)	0	.057
Pteromalidae, undetermined spp.	.008	.037
Pteromalus cassotis Walker	0	.007
Spilochalcis albifrons (Walsh)	.008	.007
Spilochalcis flavopicta (Cresson)	0	.007
Spilochalcis igneoides (Kirby)	.016	.007
Spilochalcis sanguiniventris (Cresson)	.016	.030
Spilochalcis side (Walker)	.008	.007
Tretrastichini, undetermined spp.	0	.015
Tetrastichus hunteri Crawford	0	.015
Tetrastichus marylandensis (Girault)	0	.007
Tetrastichus spp.	.024	.037
Zatropis orontas (Walker)	.070	.165
Zatropis insertus (Ashmead)	0	.007
Zatropis tortricidis Crawford	.005	.023
Cynipidae:		
Aporeucoela spp., female	0	.007
Aspiceratinae, undetermined spp.	0	.007
Eucoila spp.	0	.007
Eucoilinae, new genus	.024	.007
Eucoilinae, undetermined spp.	0	.045
Hexacola spp.	0	.007
Prosaspicera similis (Ashmead); 2 males, 3 females	.008	.030
Pseudeucoila spp., male	0	.007
Trybliographa spp.	0	.007
Undetermined spp.	.024	.007
Formicidae:		
Aphaenogaster spp.	0	.007
Camponotus spp.	0	.007
Crematogaster spp.	.008	.015
Dolichoderinae, undetermined spp.	0	.060
Dorymyremex spp.	.016	.052
Monomorium spp.	0	.007
Pheidole spp.	.008	.007
Pogonomyrmex barbatus (Smith)	0	.007
Solenopsis spp.	.080	.225
Undetermined spp.:		
Ants	3.776	5.680
Winged ants	.008	.007
Halictidae:		
Agapostemon texanus Cresson	.16	.045
Dialictus coactus (Cresson)	0	.015

See footnotes at end of table.

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hymenoptera—Continued:		
Halictidae—Continued:		
Dialictus disparilis (Cresson)	0	0.098
Dialictus spp.	.032	.023
Halictus ligatus Say	.008	0
Undetermined spp.	.040	.015
Ichneumonidae:		
Charops annulipes Ashmead, females	0	.007
Mesostenus longicaudis (Cresson), females	.008	.007
Pristomerus spinator (Fabricius), males	.008	.023
Temelucha forbesi Weid, females	0	.007
Undetermined spp.	0	.075
Megachilidae, *Megachile texana* Cresson	.008	.007
Scelionidae:		
Baryconus spp.	0	.007
Calotelea marlattii Ashmead	.008	.007
Gryron spp.	.009	0
Macroteleia macrogaster Ashmead	0	.023
Scelio spp.	.008	.007
Telenomus spp.	.016	.023
Trimorus spp.	.008	.007
Trimorus n. spp.	.032	.052
Undetermined spp.	0	.007
Sphecidae:		
Cerceris serripes (Fabricius)	0	.007
Entomognathus spp.	0	.007
Lires argentata (Beauvois)	0	.007
Pluto tibialis (Cresson)	.024	.045
Sceliphron caementarium (Drury)	.032	0
Tachytes abdominalis (Say)	0	.007
Tiphiidae:		
Myzinum quinquecinctum (Fabricius)	0	.052
Tiphia intermedia Malloch	0	.007
Undetermined spp.	6.230	4.677
Vespidae:		
Eudodynerus annulatus annulatus (Say)	0	.007
Eudodynerus hidalgo hidalgo (Saussure)	0	.007
Polistes annularis (Linnaeus)	.008	.015
Polistes apachus Saussure	0	.007
Polistes exclamans exclamans Viereck	0	.015
Stenodynerus anormis (Say)	.008	.007
Neuroptera:		
Chrysopidae:		
Chrysopa oculata Say	.061	0
Chrysopa rufilabris Burmeister	.02	0
Chrysopa spp.:		
Adults	.061	.019
Larvae	.061	.019
Myrmeleontidae; undetermined ant lions, adults	.081	.111

See footnotes at end of table.

Table 8.—Entomophagous arthropods collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Entomophagous species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Odonata:		
Anisoptera, undetermined spp.	0.031	0.065
Undetermined spp.	0	.019
Zygoptera, undetermined spp.	.02	.019
Orthoptera; Mantidae, undetermined spp.	.071	.067
Average number of entomophagous species collected	45.76	39.01

[1]12,600 total sweeps taken in area Y.
[2]13,300 total sweeps taken in area W.

vittatus (Say). *C. balteatus* eats eggs of the bollworm moth (Ewing and Ivy 1943). They were collected mostly in sweepings over the evening primrose, *Oenothera biennis*. Numerous small, shiny black beetles belonging to Phalacridae were collected. They were often seen in aphid colonies on cotton feeding on the nymphs. They were collected most abundantly on *Parthenium*, but appeared in sweepings generally. Plant lice were often found on *Parthenium*, which may account for the large number of phalacrids found on this plant.

Diptera.—With so many species of Diptera taken in the collections, it was difficult to determine or differentiate the beneficial or directly injurious species belonging to certain families. Some species in a single family may be considered entomophagous, and others definitely injurious. There were about 676 specimens collected in the sweepings over the weed association that were known to be more or less beneficial. The families represented were the Asilidae, Bombyliidae, Dolichopodidae, Drosophilidae, Sarcophagidae, Syrphidae, and Tachinidae. They included parasitic as well as predaceous species.

Hemiptera.—Some of the most beneficial insects occur in Hemiptera. The families represented in the entomophagous species were the Anthocoridae, Lygaeidae, Nabidae, Phymatidae, and Reduviidae. Probably the most important and valuable insect to the cotton farmer is the anthocorid *Orius insidiosus* in its role as a predator of bollworm eggs. It is ever present in flowers of *Erigeron*, Indian blanket, *Gaillardia pulchella*, and other Compositae. The nabids *Nabis alternatus* Parshley and *N. capsiformis* (Germar) were commonly taken in weeds and are often seen in the cotton as well as feeding on injurious cotton insects. Several specimens of the phymatids *Phymata fasciata georgiensis* Melin and other *Phymata* spp. were collected. The phymatids are predaceous and were occasionally seen in cotton blossoms, where adults usually conceal themselves watching for insects, which often include fleahopper nymphs. Numerous species of reduviids were taken. The reduviids are particularly beneficial, feeding on bollworm and leafworm eggs as well as on small lepidopterous larvae and mirid nymphs. The species represented were *Arilus cristatus* (Linnaeus), *Atrachelus cinereus* (Linnaeus), *Sinea confusa* Caudell, *S. diedema* (Fabricius), *S. spinipes* (Fabricius), *Zelus renardii* Kolenati, and *Z. socius* (Uhler).

Hymenoptera.—There were more species among the Hymenoptera than any other order. The families represented by beneficial species were Andrenidae, Apidae, Bethylidae, Bombidae, Braconidae, Chalcidoidea, Cynipidae, Formicidae, Halictidae, Ichneumonidae, Megachilidae, Scelionidae, Sphecidae, Tiphiidae, and Vespidae.

One of the parasites most often collected was the braconid *Bracon mellitor*, parasitic on the boll weevil. The aphid parasite *Lysiphlebus testaceipes* was frequently taken, though not in the sweepings reported in table 8. This parasite may build up very rapidly. It may complete its life cycle in 7 days (Clausen 1940a, 1940b), and one female may contain as many as 430 eggs at one time. During a single season, the writer has noted

many generations, especially when the weather is hot and damp. At times, as many as 182 parasitized aphids have been taken from a single leaf.

The superfamily Chalcidoidea includes mostly beneficial species. Over 83 species were collected, and a few are of particular interest in the biological control of cotton insects. Among those were *Euplectrus comstockii* Howard (Eulophidae-Elachertinae), a parasite of the cotton leafworm, and *E. plathypenae* Howard, a gregarious external parasite of half-grown or larger larvae of various Noctuidae, particularly *Laphygma* and *Cirphus*.

The ants, Formicidae, are beneficial because of their predaceous habits. They kill many boll weevil larvae in fallen squares, and attack bollworms and leafworms and many other injurious insects. Ants are ever present in the cottonfields, feeding on the honeydew secreted by the aphids, or on the foliar nectaries of the cotton leaf. They were collected in considerable numbers both in weeds and cotton. The genera represented in the collections on weeds were *Aphaenogaster, Camponotus, Monomorium, Pheidole, Pogonomyrmex,* and *Solenopsis.*

A small hymenopteran, *Pachyneuron siphonophorae* (Ashmead) of the family Pteromalidae, was frequently taken in weeds, though not in the sweepings reported in table 8. It may occur as a primary or secondary parasite; although, if the latter, it is hyperparasitic on *Lysiphlebus testaceipes.* Forsum and Bondy (1930) recorded it as an important primary parasite of *Aphis gossypii* Glover. Muesebeck et al. (1951) included this aphid, as well as *L. testaceipes,* as hosts of this parasite. Howard (1890) also mentions species of *Pachyneuron* occurring on aphids. Its greatest abundance was found by the writer to be during the first week in July. In August it became more scarce, but it still occurred in greater numbers than *L. testaceipes.*

Neuroptera.—*Chrysopa rufilabris* Burmeister and *C. oculata* Say, important predatory lacewing flies, were often collected in weeds.

Odonata.—Dragonflies and damselflies were frequently collected in weeds and in cotton on the watershed. Khan and Afzal (1950) reported having collected them on cotton in Pakistan and concluded that the cotton flowers were a source of great attraction to the dragonflies. Dragonflies are, of course, very beneficial as predators of insects in general.

Orthoptera.—Most Orthoptera are phytophagous, although a few species are predaceous or omnivorous. Orthoptera considered as partly beneficial were tree crickets. The praying mantis, *Mantis* spp., of the family Mantidae, was often collected and is very beneficial. These two species commonly occur in weeds, although they may transfer to cultivated crops, especially cotton.

Injurious Insects in Weeds

Between 1942 and 1949, 41,499 insects that were considered injurious to miscellaneous crops or vegetation were collected in the weed association. Those injurious to cotton are listed here (table 9).

Coleoptera.—A total of 4,043 specimens of injurious Coleoptera were collected. Although the comparative numbers were small, comprising only 10% of the total insects collected for all orders, many species were of great importance, causing major damage to cotton. The most important families of injurious Coleoptera were Bruchidae, Cantharidae, Cerambycidae, Chrysomelidae, Cisidae, Curculionidae, Elateridae, Languriidae, Mordellidae, and Scolytidae.

The chrysomelids included about 52% of the injurious specimens of Coleoptera taken in the sweepings. Over 40 known species were represented. Although many of them frequently were seen in cotton, only a few were observed to feed on cotton, eating the young leaves and blossoms. The corn flea beetle, *Chaetocnema pulicaria* Melsheimer, has been observed feeding in the blossoms on pollen and making small holes in the tender leaves. The western black flea beetle, *Phyllotreta pusilla* Horn, has also been observed doing similar damage to cotton. The flea beetles appeared more commonly in the sweepings over blossoms of the evening primrose, *Oenothera,* and on Indian blanket. The western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* Mannerheim, was often collected and was frequently seen in the cotton blossoms feeding on petals, at times destroying the blossom. The grape colaspis, *Colaspis brunnea* (Fabricius), was often collected. It was found feeding on the leaves and blossoms and is known to do some damage to cotton. The Colorado potato beetle, *Leptinotarsa decemlineata* (Say), was occasionally collected in the weeds, especially

(*Continued on page 49.*)

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y. 1943–44 and 1947–49

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Coleoptera:		
Anthribidae, *Trigonorhinus alternatus* (Say)	0.008	0
Bostrichidae, *Rhizopertha* sp.	0	.015
Bruchidae:		
Algarobius bottimeri Kingsolver	0	.007
Mimosestes amicus (Horn)	0	.014
Mimosestes nubigens (Motschulsky)	0	.007
Mimosestes protractus (Horn)	0	.007
Mimosestes sp.	.008	.015
Undetermined spp.	.040	.052
Buprestidae:		
Acmaeodera pulchella Herbst	.111	.023
Agrilus lacustris LeConte	.016	0
Taphrocerus sp.	.008	0
Cantharidae, *Chauliognathus scutellaris* LeConte	.161	.060
Cerambycidae:		
Batale suturalis (Say)	.067	.007
Mecas cana saturnina (LeConte)	.016	0
Mecas pergrata (Say)	0	.030
Undetermined spp.	.032	.007
Chrysomelidae:		
Acalymma vittata (Fabricius)	.016	.037
Altica foliacea LeConte	.056	7.87
Altica sp.	.040	.075
Anomoea rufifrons hoegei Jacoby	.056	.21
Calomicrus varicornis (LeConte)	.016	.015
Capraifa texana (Cresson)	.143	.436
Chaetocnema pulicaria Melsheimer	.373	.406
Chrysomela scripta Fabricius	0	.015
Colaspis brunnea (Fabricius)	0	.007
Colaspis sp.	0	.007
Cryptocephalus venustus Fabricius	.016	.015
Deloyala guttata (Olivier)	.008	.023
Diabrotica cristata (Harris)	.008	.090
Diabrotica tibialis Jacoby	.008	0
Diabrotica undecimpunctata undecimpunctata Mannerheim	.079	.067
Diachus auratus (Fabricius)	.063	.037
Disonycha admirabilis (Blatchley)	0	.037
Disonycha arizonae Casey	0	.060
Disonycha fumata quinquerutata Schaeffer	.008	.015
Disonycha triangularis (Say)	0	.007
Disonycha xanthomelas (Dalman)	.008	0
Epitrix fasciata Blatchley	0	.074
Epitrix hirtipennis (Melsheimer)	.008	.023
Epitrix sp.	.111	.301
Glyptina sp.	.016	.173
Kuschelina fimbriata (Förster)	.008	0
Leptinotarsa decemlineata (Say)	.032	.052
Longitarus varicornis Suffrian	.254	.007
Luperodea sp.	0	.007
Metriona bicolor (Fabricius)	0	.007

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Coleoptera—Continued:		
Chrysomelidae—Continued:		
Monoxia sp.	0.048	0
Nodonota texana Schaeffer	0	.015
Nodonota tristis (Olivier)	0	.007
Nuzonia pallidula (Boheman)	.048	.030
Ophraella notulata (Fabricius)	0	.090
Pachybrachis atomarius (Melsheimer)	0	.023
Pachybrachis bivittatus (Say)	0	.007
Pachybrachis diversus Fallen	.128	.075
Pachybrachis immaculatus Jacoby	.040	.278
Pachybrachis litigiosus Suffrian	.032	.030
Pachybrachis othomus pallidipennis Suffrian	0	.067
Pachybrachis sp.	.294	.158
Phyllotreta pusilla Horn	2.28	.315
Syphrea nana (Crotch)	0	.037
Systena sp.	.032	.361
Typophorus nigritus viridicyaneus (Crotch)	0	.015
Undetermined spp.	.095	.045
Zygogramma disrupta (Rogers)	.032	.052
Cisidae, *Euphoria* sp.	.008	0
Cleridae, *Trichodes bibalteatus* LeConte	.071	0
Curculionidae:		
Anacentrinus blanditus (Casey)	.008	0
Anacentrinus deplanatus (Casey)	0	.030
Anacentrinus sp.	0	.007
Anacentrinus planiusculus (Casey)	0	.007
Anthonomus abopilosus Dietz	.008	0
Anthonomus heterothecae Pierce	0	.007
Anthonomus sp.	0	.015
Anthonomus squamosus LeConte	0	.007
Apion metallicum Gerstaecker	.040	.015
Apion sp.	.016	.023
Auleutes asper LeConte	0	.007
Auleutes sp.	.016	0
Baris sp.	0	.037
Compsus auricephalus (Say)	.016	.030
Conotrachelus leucophaeatus Fahraeus	0	.007
Conotrachelus nivosus LeConte	.008	0
Curculio proboscideus Fabricius	0	.007
Curculio victoriensis Chittenden	0	.023
Cylindrocopturus adspersus (LeConte)	0	.045
Cylindrocopturus nanulus (LeConte)	.190	1.52
Cylindrocopturus sp.	.159	.16
Epicaerus imbricatus (Say)	.008	.007
Hypera punctata (Fabricius)	0	.007
Hyperodes sp.	0	.007
Lignyodes horridulus (Casey)	0	.007
Lixus oregonus Casey	.008	.030
Lixus scrobicollis Boheman	.008	.007
Lixus tenellus Casey	.008	.007

See footnotes at end of table.

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Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Coleoptera—Continued:		
Curculionidae—Continued:		
Madarellus (*undulatus* Say s.l.)	0	0.007
Myrmex uniformis Champion	0	.007
Odontocorynus sp.	0	.015
Pantomorus elegans (Horn)	0	.128
Semicronyx constrictus (Say)	.008	0
Semicronyx sp.	0	.007
Semicronyx ovipennis LeConte	0	.030
Sphenophorus coesifrons Gyllenhal	.008	0
Stictobaris cribata (LeConte)	.008	0
Thecesternus affinis LeConte	0	.030
Undetermined spp.	.571	.75
Dermestidae, undetermined spp.	0	.007
Elateridae:		
Conoderus vespertinus (Fabricius)	.024	.030
Glyphonyx sp.	0	.007
Undetermined spp.	.032	.023
Eucnemidae, *Deltometopus amoenicornis* (Say)	.008	0
Languriidae, undetermined spp.	.008	0
Meloidae:		
Epicauta atrata (Fabricius)	0	.023
Epicauta callosa LeConte	1.98	1.203
Epicauta maculata Say	.06	0
Epicauta pennsylvanica (De Geer)	.008	0
Epicauta pseudosolani Dillon	.008	0
Epicauta sericans LeConte	.040	.060
Epicauta sp.	.532	.895
Nemognatha lurida LeConte	.06	0
Pyrota sp.	0	.007
Mordellidae:		
Mordella sp.	0	.007
Mordellistena sp.	.071	.165
Undetermined spp.	.071	.211
Scolytidae, *Phloeosinus* sp.	.008	0
Tenebrionidae, *Bothrotes canaliculatus acutus* (LeConte)	0	.007
Undetermined spp.	1.81	2.79
Hemiptera:		
Berytidae:		
Jalysus sp.	.008	0
Jalysus wickhami Van Duzee	.032	.023
Coreidae:		
Arhyssus lateralis (Say)	.016	.037
Aufeius impressicollis Stal	.008	0
Catorhintha guttula (Fabricius)	0	.007
Catorhintha selector Stal	.032	0
Chariesterus antennator (Fabricius)	.008	.007
Euthochtha galeator (Fabricius)	0	.007
Exptochiomera fuscicornis (Stal)	0	.007
Exptochiomera sp.	.068	.007
Harmostes fraterculus (Say)	0	.007

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera—Continued:		
Coreidae—Continued:		
Harmostes reflexulus (Say)	1.50	1.09
Hyalymenus tarsatus (Fabricius)	.016	.015
Jadera haematoloma (Herrich-Schaeffer)	.016	.007
Leptoglossus phyllopus (Linnaeus):		
Adults	.063	.067
Nymphs	.040	.023
Liorhyssus hyalinus (Fabricius)	.111	.067
Liorhyssus sp.	.040	0
Mercoris sp.	.008	.007
Mercoris typhaeus (Fabricius)	0	.007
Mozena lunata (Fabricius)	0	.007
Niesthrea sidae (Fabricius)	.008	.030
Stachyocnemus apicalis Dallas	.016	0
Undetermined spp:		
Adults	.05	.25
Nymphs	.024	.067
Cydnidae:		
Corimelaena marginella Dallas	.032	.218
Galgupha carinata McAtee & Malloch:		
Adults	.722	6.99
Nymphs	.333	2.05
Lygaeidae:		
Blissus leucopterus leucopterus (Say)	0	.007
Cymus breviceps Stal	0	.007
Cymus sp.	0	.007
Lygaeus kalmii Stal	.032	.030
Lygaeus sp.	.016	.030
Melanopleurus belfragei (Stal)	.008	0
Nysius californica (Boisduval)	.571	1.12
Nysius raphanus Howard	.246	.067
Nysius sp.	.016	0
Oncopeltus fasciatus (Dallas)	0	.007
Ortholomus scolopax (Say):		
Adults	.024	1.11
Nymphs	.500	.55
Paromius longulus (Dallas)	0	.098
Perigenes constrictus (Say)	.008	0
Phlegyus abbreviatus (Uhler)	.008	0
Taylorilygus pallidulus (Blanchard)	.018	.052
Undetermined spp.	.024	.023
Miridae:		
Adelphocoris rapidus (Say):		
Adults	.865	.31
Nymphs	.126	.66
Ceratocapsus fuscosignatus Knight	0	.075
Ceratocapsus punctulatus (Reuter)	.016	0
Calocoris sexmaculatus (Barber)	.032	0
Cyrtopeltis melanocephala Reuter	.008	0
Dagbertus fasciatus var. *viridiusculus* (Knight)	.008	.015

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera—Continued:		
Miridae—Continued:		
Lygocoris pabulinus (Linnaeus)	0.008	0.24
Lygus lineolaris (Palisot de Beauvois)	.008	.052
Oncerometopus nigriclavis Reuter	.024	.037
Polymerus basalis (Reuter):		
Adults	4.60	1.98
Nymphs	.008	.015
Pseudatomoscelis seriatus (Reuter):		
Adults	2.05	1.45
Nymphs	.008	.023
Reuteroscopus ornatus (Reuter)	.817	.598
Rhinacloa forticornis Reuter	1.95	.023
Sixeonotus areolatus Knight	.008	.015
Sixeonotus insignis Reuter	.018	.030
Spanagonicus albofasciata (Reuter)	0	.008
Trigonotylus doddi (Distant)	.024	.18
Trigonotylus pulcher Reuter:		
Adults	24.39	.105
Nymphs	.063	.023
Undetermined spp.	.016	3.11
Pentatomidae:		
Brochymena cariosa Stal	0	.007
Chlorochroa ligata (Say)	0	.007
Corimelaena lateralis (Fabricius)	.024	.023
Corimelaena pulicari (Germar)	.032	.052
Euschistus servus (Say)	.032	.037
Hymenarcys nervosa (Say):		
Adults	.214	.17
Nymphs	0	.053
Mecidea longula Stal:		
Adults	.111	.143
Nymphs	.032	.045
Nezara viridula (Linnaeus)	.040	.030
Oebalus pugnax (Fabricius):		
Adults	1.84	2.02
Nymphs	.040	.293
Podisus acutissimus Stal	.040	.023
Podisus maculiventris (Say)	0	.023
Stiretrus anchorago (Fabricius)	0	.007
Thyanta accera McAtee	.040	.045
Thyanta custator (Fabricius):		
Adults	.262	.55
Nymphs	.008	.053
Thyanta sp.	0	.015
Trichopopla semivittatta (Say):		
Adults	.103	.256
Nymphs	.008	0
Trichopopla sp.	0	.037

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Hemiptera—Continued:		
Pentatomidae—Continued:		
Undetermined spp.:		
Adults	0.040	0.08
Nymphs	.659	.632
Piesmatidae:		
Piesma cinereum (Say)	0	.142
Undetermined spp.:		
Adults	.008	.007
Nymphs	0	.015
Pyrrhocoridae, *Largus cinctus* (Herrich-Schaeffer)	0	.007
Tingidae:		
Corythuca sp.	0	.007
Gargaphia solani Heidemann	.032	.007
Leptoypha mutica (Say)	.008	0
Undetermined spp.	.008	.50
Undetermined spp.:		
Adults	.040	.16
Nymphs	.119	.015
Homoptera:		
Aphiidae:		
Rhopalosiphum sp.	.016	0
Undetermined spp.	.571	.17
Cercopidae:		
Clastoptera xanthocephala Germar, adults	2.65	3.08
Lepyronia gibbosa Ball	.587	.72
Lepyronia quadrangularis (Say)	.006	0
Undetermined spp.	.048	.24
Cicadellidae:		
Aceratagalla sp.	.865	0
Aceratagalla uhleri (Van Duzee)	.317	.120
Belclutha neglecta (DeLong & Davidson)	.683	.33
Chlorotettix spatulatus Osborn & Ball, adults	0	.007
Chlorotettix viridis Van Duzee:		
Adults	2.032	1.32
Nymphs	0	.060
Ciminius harti (Ball)	.532	.39
Draeculacephala portola Ball	2.60	.53
Empoasca abrupta DeLong	5.87	12.38
Empoasca fabae (Harris)	5.79	17.65
Empoasca sp.	1.06	2.62
Exitianus exitiosus (Uhler):		
Adults	.627	.997
Nymphs	0	.052
Flexamia curvata DeLong	.056	0
Flexamia producta (Walker)	0	.023
Flexamia reflexa (Osborn & Ball)	0	.007
Graminella nigrifrons (Forbes)	0	.007
Graminella sonoua (Ball)	.008	0
Graphocephala hieroglyphica (Say)	0	.015
Graphocephala sp.	.087	0
Graphocephala versuta (Say)	.286	.65

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Homoptera—Continued:		
Cicadellidae—Continued:		
Homalogisca coagulata (Say)	0.055	0.015
Macrosteles fascifrons (Stal)	.056	0
Mesamia straminea (Osborn)	.008	.007
Negosiana miliaris (Stal)	0	.007
Neocoelidia sp.	0	.007
Norvellina seminuda (Say)	.008	0
Oncometopia lateralis (Fabricius):		
Adults	.262	.35
Nymphs	0	.007
Oncometopia orbona (Fabricius)	.008	.007
Scaphytopius frontalis (Van Duzee)	.095	.113
Scaphytopius fulginosus (Osborn)	0	.015
Scaphytopius irroratus (Van Duzee):		
Adults	.119	.22
Nymphs	0	.007
Scaphytopius sp.	.032	.09
Stirellus bicolor (Van Duzee)	.182	.26
Stragania robusta (Uhler)	.008	.007
Texananus areolatus (Baker)	.048	.023
Texananus exultus (Uhler)	.016	.030
Texananus sp.	.024	.060
Texananus spatulatus (Van Duzee)	.008	0
Tinobregmus vittatus Van Duzee:		
Adults	.111	.095
Nymphs	.032	0
Trypomans sp.	.008	.007
Undetermined spp.:		
Adults	1.56	1.65
Nymphs	.913	1.95
Xerophloea virdis (Fabricius)	.055	.075
Fulgoridae:		
Acanalonia bivittata (Say)	0	.067
Acanalonia laticosta Doering	2.00	.98
Bruchomorpha sp.	.008	.007
Cixius stigmatus (Say)	.006	.023
Dictyonissus griphus Uhler:		
Adults	.698	3.36
Nymphs	.024	.113
Dictyonissus sp.	.040	.263
Metcalfa pruinosa (Say)	.016	0
Nersia sp.	.270	.22
Oliarus aridus Ball	1.127	2.08
Oliarus concinnulus Fowler	.040	.082
Oliarus sp.	.056	.030
Pissonotus sp.	.024	0
Scolops pugens (Germar)	.508	1.52
Scolops sp.	.032	.26
Undetermined spp.	.024	.075

See footnotes at end of table.

Table 9.—**Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued**

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Homoptera—Continued:		
Membracidae:		
Campylenchia latipes (Say)	22.88	48.30
Entylia consisa Walker	0	.007
Entylia sinuata (Fabricius)	.040	.037
Micrutalis calva (Say):		
Adults	.079	1.54
Nymphs	0	.030
Stictocephala bisonia Kopp & Yonke	.048	.007
Stictocephala festinus (Say)	3.17	2.83
Stictocephala sp.	.127	.045
Undetermined spp.	.174	.23
Vanduzea laeta var. *segmentata* (Fowler)	.143	.87
Psyllidae:		
Aphalara sp.	.040	0
Craspedolepta minuta (Caldwell)	.048	.29
Heteropsylla texana Crawford	0	.007
Pachypsylla celtidisgemma Riley	.373	.007
Pachypsylla celtidismamma (Riley)	.016	.105
Psylla sp.	.008	.007
Trioza diospyri (Ashmead)	.024	.007
Undetermined spp.	0	.007
Hymenoptera:		
Aspiceratinae, *Prosaspicera similis* (Ashmead)	.032	.007
Chalcididae, *Brachymeria compsilurae* (Crawford)	0	.007
Eurytomidae, *Bruchophagus gibbus* (Boheman)	.008	.045
Mutillidae:		
Dasymutilla quadrigutatta (Say)	0	.015
Pseudomethoca oceola (Blake)	0	.007
Torymidae, *Podagrion mantis* Ashmead	0	.007
Lepidoptera:		
Arctiidae, *Estigmene acrea* (Drury):		
Adults	.008	0
Larvae	0	0
Geometridae, undetermined spp., larvae	.278	.39
Hesperiidae:		
Epagyreus clarus (Cramer), adults	.008	.037
Hesperia sp.	0	.023
Undetermined spp., adults	.008	0
Lycaenidae, *Strymon melinus* (Hübner):		
Adults	.095	.060
Larvae	.016	0
Microlepidoptera, undetermined spp., adults	.238	.60
Noctuidae:		
Heliothis zea (Boddie):		
Adults	.048	.751
Larvae	.198	.128
Trichoplusia ni Hübner	.198	.150
Undetermined spp., larvae	.151	.113

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943-44 and 1947-49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Lepidoptera—Continued:		
Nymphalidae:		
Lepidopterous larvae	0.611	0.26
Phycoides sp.	.016	.007
Pieridae:		
Artogeia rapae (Linnaeus), adults	.032	0
Colias eurytheme Boisduval, adults	.016	0
Nathalis iole Boisduval	.024	0
Pyralidae:		
Achyra rantalis (Guenée)	.040	.037
Desmia funeralis (Hübner)	0	.015
Undetermined spp., adults	.222	.075
Orthoptera:		
Acrididae:		
Chortophaga viridifasciata (De Geer)	.008	.015
Dissosteira carolina (Linnaeus)	.008	0
Encoptolopus sp.	.151	.098
Encoptolopus subgracilis texensis Brunner	0	.007
Grasshopper, undetermined spp.:		
Adults	1.761	1.59
Nymphs	7.111	6.33
Hadrotettix trifasciata (Say):		
Adults	.016	.052
Nymphs	.024	0
Hesperotettix speciosus Scudder:		
Adults	.317	.632
Nymphs	.016	.256
Hesperotettix viridis (Thomas):		
Adults	.222	.594
Nymphs	0	.128
Hippiscus rugosus Scudder	.008	.030
Melanoplus bispinosus Scudder	.008	0
Melanoplus differentialis (Thomas):		
Adults	5.71	1.396
Nymphs	.786	1.21
Melanoplus femurrubrum (De Geer):		
Adults	.167	.211
Nymphs	0	.015
Melanoplus foedus Scudder	.008	0
Melanoplus mexicanus Saussure	.159	.233
Melanoplus texanus (Scudder)	0	.037
Mermiria maculipennis Brunner:		
Adults	.056	.180
Nymphs	.008	.015
Mermiria sp.	0	.007
Mermiria texana (Brunner):		
Adults	.008	.188
Nymphs	0	.007
Orphulella pelidna pelidna (Burmeister):		
Adults	.048	.534
Nymphs	.158	.053

See footnotes at end of table.

Table 9.—Injurious insects collected in grass and weeds near selected cottonfields of the Y and W areas after improved cultural practices had been put into operation on area Y, 1943–44 and 1947–49—Continued

Injurious species collected	Average No. collected per 100 sweeps	
	Area Y[1]	Area W[2]
Orthoptera—Continued:		
Acrididae—Continued:		
Schistocerca americana (Drury)	0.024	0.007
Schistocerca obscura (Fabricius)	0	.023
Spharagemon collare (Scudder)	.016	0
Syrbula admirabilis (Uhler)	.063	.105
Trimerotropis citrina Scudder	.006	0
Xanthippus corallippus Haldeman	.02	.023
Blattidae, undetermined spp.	.024	0
Gryllacrididae; Gryllacridinae, undetermined spp.	.008	0
Gryllidae:		
Oecanthus argentinus Saussure:		
Adults	.286	.180
Nymphs	.015	0
Oecanthus quadripunctatus Beutenmüller	0	.007
Oecanthus spp.		
Adults	.437	.331
Nymphs	.056	.037
Phasmatidae, undetermined spp., nymphs	.071	.067
Tettigoniidae:		
Amblycorpha oblingifolia (De Geer)	.008	0
Amblycorpha sp.	.016	.007
Arethaea gracilipes (Thomas)	0	.015
Arethaea sp.	.014	.060
Atlanticus americanus Rehn	.008	0
Conocephalinae, undetermined spp.	.103	.015
Conocephalus fasciatus (De Geer)	.111	.067
Microcentrum sp.	.016	.023
Neoconocephalus ensiger Harris:		
Adults	.040	.015
Nymphs	.087	.083
Neoconocephalus triops (Linnaeus)	.016	0
Orchelimum pulchellum Davis	.032	.345
Phaneropterinae, undetermined spp.:		
Adults	.056	.015
Nymphs	.016	0
Scudderia furcata Brunner von Wattenwyl	.040	.030
Scudderia sp.	.103	.113
Undetermined spp.:		
Adults	.032	.045
Nymphs	.016	0
Total of averages of injurious insects collected	129.17	187.20

[1] 12,600 total sweeps taken in area Y.
[2] 13,300 total sweeps taken in area W.

on *Solanum*, and was often seen on the cotton plants, the adults feeding on the leaves. *Altica foliacea* LeConte was collected in considerable numbers in *Parthenium*, as well as on cotton. This small chrysomelid was observed both by the writer and Folsum (1936b) to feed on terminal leaves and buds of cotton.

There were 32 curculionid species collected, representing 24 genera, mostly of little-known importance to cotton. *Compsus auricephalus* has been observed feeding on cotton seedlings by the writer and by Folsum (1936a). The tobacco wireworm, *Conoderus vespertinus*, was the only known elaterid collected, although many undetermined adults were taken. This species is recorded as doing considerable damage to cotton in South Carolina and has been observed by the writer on cotton roots in Louisiana. The adults were also found to damage young squares and to feed on the leaves.

Hemiptera.—In the Y and W areas, 11,367 specimens of Heteroptera, or over 27% of the total insects collected were considered injurious. The families represented were Berytidae, Coreidae, Cydnidae, Lygaeidae, Miridae, Pentatomidae, Piesmatidae, Pyrrhocoridae, and Tingidae. Most injurious insects affecting the cotton plant, with the exception of the boll weevil and cotton leafworm, may be found on some wild host plant among the weed association.

Species of injurious coreids collected were *Chariesterus antennator*, *Jadera haematoloma* (Herrich-Schaeffer), *Leptoglossus phyllopus* (Linnaeus), and *Niesthrea sidae*. *J. haematoloma* is often seen in the cottonfields, although it is doubtful if it ever does material damage (Little and Martin 1941a, 1941b, 1941c, 1941d).

The lygaeids comprised about 6% of the numbers of injurious Hemiptera collected. The species known to affect cotton were *Nysius raphanus* and *Oncopeltis fasciatus* (Dallas). The latter occasionally attacks bolls and squares (Little and Martin 1941a, 1941b, 1941c, 1941d), and *N. raphanus* attacks cotton in the southern San Joaquin Valley in California (Essig and Hoskins 1944).

The mirids comprised over 67% of the total injurious specimens of Hemiptera collected in the weed and grass association. Those species taken that are of primary importance in attacking cotton were *Adelphocoris rapidus*, *Lygocoris pabulinus* (Linnaeus), *Lygus lineolaris*, and *Pseudatomoscelis seriatus*. The *Lygus* spp. are usually common on leguminous cover crops and on wild host plants as fleabane (*Erigeron*) and other Compositae. Other mirids were *Rhinacloa forticornis* Reuter and *Spanogonicus albofasciata* (Reuter), now considered as primarily predaceous.

Numerous species of pentatomids were collected, many of them directly injurious to cotton. Those known to cause damage were *Chlorochroa ligata* (Say), *Euschistus servus* (Say), *Nezara viridula*, *Podisus maculiventris*, *Stiretrus anchorago* (Fabricius), and *Thyanta custator*. *T. custator* was the predominant species causing damage to cotton on the watershed, especially injuring bolls. It appeared that the adults flew from the weeds into the cover crops, such as Madrid clover and hubam, and built up a large population. When these cover crops were cut, the adults then transferred their attacks to the nearby cotton and damage became appreciable. The pyrrhocorid, *Largus cinctus* (Herrich-Schaeffer), is sometimes injurious to cotton, attacking squares and bolls.

Homoptera.—Of the total injurious insects collected in the grass and weed association, the 21,598 specimens of Homoptera comprised 52%. The families included Aphididae, Cercopidae, Cicadellidae, Fulgoridae, Membracidae, and Psyllidae. Though aphids, Aphididae, are very injurious to cotton, none collected on weeds were of the species known to affect cotton. Of the total Homoptera, 8,636 cicadellids, or about 40%, were collected. There were about 34 species represented, with the potato leafhopper, *Empoasca fabae*, comprising 36% of the total taken, and the western potato leafhopper, *E. abrupta*, over 27%. Both species are abundant in weeds, especially on *Solanum*. They are serious pests of vegetables, particularly potatoes and beans. They are often seen in cotton, and *E. abrupta* is recorded as damaging cotton in California (Essig and Hoskins 1944). Both species no doubt were the cause of some damage to cotton on the watershed, as the white stippling effect of the leaves followed by drying was observed on plants where these two species occurred abundantly. Other species known to damage cotton were the common sharpshooters *Homalogisca coagulata* and *Oncometopia orbona*; *Cuerna costalis* was also taken, but not in the sweepings reported in table 9. The leafhopper *Graphocephala versuta* was also taken in considerable numbers.

Hymenoptera.—Only a few of the Hymenoptera collected were considered injurious. The

families represented were Aspiceratinae, Chalcididae, Eurytomidae, Mutillidae, and Torymidae. None were known to be directly injurious to cotton, although a few are parasitic on beneficial insects. One such species collected, *Brachymeria compsilurae* (Crawford), a chalcidid, is parasitic, particularly in dead lepidopterous larvae or pupae containing tachinid maggots (Clausen 1940a, 1940b).

Lepidoptera.—The lepidopteran families represented were Arctiidae, Geometridae, Hesperidae, Lycaenidae, Noctuidae, Nymphalidae, Pieridae, and Pyralidae. Both adults and larvae of the arctiid saltmarsh caterpillar, *Estigmene acrea* (Drury), were frequently collected. The larvae are polyphagous and were collected on many species of weeds and grasses. Their defoliation of cotton is often appreciable. But, at times, the injury is negligible, since the maximum abundance may come late in the season when the cotton has reached maturity (Glick 1922).

The lycaenid cotton square borer, *Strymon melinus* (Hübner), was occasionally taken in the weeds. Although the injury to squares on the watershed has never been great, occasional damage was noted. The larvae may be found feeding on such weeds as *Malva parviflora* and *Croton* spp.

Both larvae and adults of the noctuid bollworm were taken in the weeds, although the larvae were usually found feeding on Indian mallow, *Abutilon;* jimsonweed, *Datura stramonium;* and little mallow, *Malva parviflora.* Adults of the cabbage looper, *Trichoplusia ni* (Hübner), were collected frequently in weeds, as were adults of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), though not in the sweepings reported in table 9, and various species of cutworm moths. Larvae of the cabbage looper are frequently found feeding on the cotton leaves, pupating in rolled-up leaves.

The pyralid garden webworm, *Achyra rantalis* (Guenée) was often collected in great numbers in the sweepings over pigweed, *Amaranthus,* and other weeds. The larvae of this moth are often very destructive to cotton, and have frequently caused damage to cotton on the watershed.

Orthoptera.—The families in Orthoptera that injured cotton on the watershed were the Acrididae, Blattidae, Gryllacrididae, Gryllidae, Phasmatidae, and Tettigoniidae. The weeds harbored many species of grasshoppers, crickets, walkingsticks, katydids, and tree crickets.

CONCLUSION

It was of importance to know what effect introduced cultural practices would have on insect abundance in cotton and other crops. Accordingly, in a given area of the Blacklands of Texas where these practices were studied over a period of years, there was found to be a considerable decrease in infestation for some cotton pests, while for others the infestation did not increase. With the introduction and continued use of cover crops, thrips damage did show an increase.

Though results in some instances may not be considered indicative, strong trends were established that indicate the potential of cultural practices in integrated pest management systems. These results should provide many ideas for future research. They also show that sound cultural practices are compatible with soil conservation.

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